ZIMBABWE ELECTRICITY REGULATORY COMMISSION

ZIMBABWE GRID CODE

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PREAMBLE

The Electricity reform program in Zimbabwe has resulted in two Acts passed by Parliament. These are the Rural Electrification Fund Act (Chapter: 13.20 5/2002) and the Electricity Act (Chapter 13: 19 4/2002). The Rural Electrification Fund Act resulted in the formation of the Rural Electrification Agency, whose mandate is to spearhead the provision of electricity in rural areas. The Electricity Act passed by the Parliament of Zimbabwe in January 2003 and gazetted on the 23rd May 2003 has led to the unbundling of ZESA to form ZESA Holdings Ltd., Zimbabwe Power Company (ZPC), Zimbabwe Electricity Transmission Company (ZETCO), Zimbabwe Electricity Distribution Company (ZEDC), ZESA Enterprises and Powertel as well as the establishment of Zimbabwe Electricity Regulatory Commission (ZERC).

ZETCO is responsible for the reliable and secure transmission of electrical energy through:

- ✓ Management and operation of the Zimbabwe's Transmission and Sub-transmission System Grid
- ✓ Planning and development of the power transmission infrastructure
- ✓ Local and regional trade facilitation (ZETCO is the single buyer of power)
- ✓ System planning and coordination of regional interconnections through SAPP

This maintains the placement of ZETCO as the key transmitter of bulk power between generators (ZPC & others) and bulk consumers (ZEDC, SAPP & others) of electrical energy through operating and maintaining the interconnected

Transmission System (the Grid) consisting of EHT lines and substations. ZETCO's responsibilities can be expanded into the following functions: -

i. Coordinate the activities of all entities especially the operation and development of the Grid and ensure fair access to all entities to the Grid.
ii. Manage and control the Grid to ensure adequacy of supply. This entails the preparation of Generation Schedules, monitoring and controlling the output of various generating stations and receiving and dispatching power from various Generators.
iii. On-Line (real-time) monitoring and control of the interconnected power System.
iv. Deliver power that conforms to specified quality characteristics to Distribution Systems at designated Connection Points
v. Carry out statutory functions under all Acts, Rules, Laws and Regulations of the Government of Zimbabwe.
vi. Develop, maintain and implement the Technical Grid Code as approved by ZERC.
vii. Responsibilities for administering Power Supply and Power Purchase agreements on behalf of ZESA Holdings.
viii. Liaison with the Zimbabwe Electricity Regulatory Commission (ZERC).
ix. Promoting power wheeling, pooling and banking

PURPOSE OF GRID CODE

ZETCO Technical Grid Code is a document approved by the Zimbabwe Electricity Regulatory Commission formulated in order to ensure efficient coordinated operation and maintenance of the electricity Grid under the restructured environment. It shall be a document agreed upon and to be complied with by ZETCO, ZPC, ZEDC, directly connected HV consumers, independent and embedded generators. The Grid Code is a dynamic document that is revised periodically as per the procedures laid down, taking into account the reasonable interests and views as expressed by the stake-holding entities in the light of the experience gained in the actual implementation of the Code.

OBJECTIVES OF THE GRID CODE

The objective of the technical Grid code is to promote sound planning, operational and connection standards in a bid to provide for reliable, secure, economic and coordinated operation of the ZETC transmission Grid. This will be achieved through the following: -

a) Specification of minimum operational standards
b) Specification of minimum technical requirements
c) Specification of information requirements and procedures
d) Governing the boundaries between ZETCO and users
e) Establishing minimum requirements for new entrants
f) Streamlining responsibilities and obligations for ZETCO and for all the users of the ZETCO transmission network
g) Establishment of requirements for the development of the ZETCO Grid

CONTENT OF THE GRID CODE

The ZETCO Technical Grid Code consists of the following Sections:

- Definitions
- Governance of the Code
- Grid Connection Code
- Performance Standards Code
- Planning Code
- Operational Code
- Metering Code
- Protection Code
- Information Exchange Code
- Project Appraisal Framework

DEFINITIONS

Amended Connection Agreement An agreement between a User and ZETCO (or the Distributor), which specifies the terms and conditions pertaining to the renovation or modification of the User System or Equipment at an existing Connection Point in the Grid (or the Distribution System).

Active Power The time average of the instantaneous power over one period of the electrical wave, measured in Watts (W) or multiples thereof. For AC circuits or systems, it is the product of the root-mean-square (RMS) or effective value of the voltage and RMS value of the in-phase component of the current. In a three-phase system, it is the sum of active power of the individual phases.

Ancillary Service Support services such as Frequency Regulating and Contingency Reserves, Reactive Power support, and Black Start capability which are necessary to support the transmission capacity and Energy that are essential in maintaining Power Quality and the Reliability and Security of the Grid.

Apparatus All equipment in which electrical conductors are used, supported or of which they may form part.

Apparent Power The product of the root-mean-square (RMS) or effective value of the current and the root-mean-square value of the voltage. For AC circuits or systems, it is the square root of the sum of the squares of the Active Power and Reactive Power, measured in volt-ampere (VA) or multiples thereof.

Automatic Generation Control (AGC) The regulation of the power output of Generating Units within a prescribed area in response to a change in system Frequency, tie-line loading, or the relation of these to each other, so as to maintain the System Frequency or the established interchange with other areas within the predetermined limits or both.

Automatic Load Shedding The process of automatically and deliberately removing pre-selected Loads from a power System in response to an abnormal condition in order to maintain the integrity of the System.

Automatic Re- closing A process used to interrupt power in the event of a fault or short circuit, and then re-instate or "re-close" the power after a fixed interval of time, with the objective of maintaining continuity of service to the greatest possible extent, without damaging equipment or creating unsafe conditions in the system.

Automatic Voltage Regulator or AVR A continuously acting automatic excitation system to control the voltage of a generating unit as measured at the generator terminals.

Availability The long-term average fraction of time that a Component or System is in service and satisfactorily performing its intended function. Also, the steady-state probability that a Component or System is in service.

Balanced Three- Phase Voltages Three sinusoidal voltages with equal frequency and magnitude and displaced from each other in phase by an angle of 120 degrees.

Black Start The process of recovery from Total System Blackout using a Generating Unit with the capability to start and synchronize with the System without an external power supply.

Botswana Power Corporation (BPC) The electrical power utility for Botswana.

Bulk Supply Point A step down substation from 330/420kV to sub transmission and /or distribution voltage levels

Capability and Availability Declaration Refers to the data submitted by the Generator for its Scheduled Generating Unit, which is used by ZETCO in preparing the day-ahead Generation Schedule. It includes declaration of capability and availability, Generation Scheduling and Dispatch Parameters

Circuit Breaker A mechanical switching device, which is capable of making, carrying, and breaking current under normal circuit conditions and also capable of making, carrying for a specified time, and breaking current under specified abnormal circuit conditions, such as a short circuit.

Competent Person A person over eighteen (18) years, who has sufficient technical knowledge and expertise to safely carry out specific tasks.

Completion Date The date, specified in the Connection Agreement or Amended Connection Agreement, when the User Development is scheduled to be completed and be ready for connection to the Grid.

Component A piece of Equipment, a line or circuit, a section of line or circuit, or a group of items, which is viewed as a unit for a specific purpose.

Connected Project Planning Data The data, which replaces the estimated values that were assumed for planning purposes, with validated actual values

Connection Agreement An agreement between a User and ZETCO (or the Distributor), which specifies the terms and conditions pertaining to the connection of the User System or Equipment to a new Connection Point in the Grid (or the Distribution System).

Connection Conditions The technical conditions to be complied with by any user having a connection to the Transmission System.

Connection Point The point of connection of the User System or Equipment to the Grid (for Users of the Grid) or to the Distribution System (for Users of the Distribution System).

Connection Point Drawings The drawings prepared for each Connection Point, which indicate the equipment layout, common protection and control, and auxiliaries at the Connection Point.

Constrained Generation Schedule The Generation Schedule prepared by ZETCO after considering operational constraints, including the Grid constraints, changes in Generating Unit Declared Data and parameters, and changes in forecasted data.

Contingency Planning A Planning Criteria that a system should meet under faulty conditions

Contingency Reserve Generating Capacity that is intended to take care of the loss of the largest Synchronized Generating Unit or the power import from a single Grid interconnection, whichever is larger. Contingency Reserve includes Spinning Reserve and Backup Reserve.

Control Centre A facility used for monitoring and controlling the operation of the Grid, Distribution System, or a User System.

Controller A senior authorised person appointed in writing by ZETCO, to control power in the transmission and sub-transmission grid, and whose duties are to maintain safety at all times to personnel, plant and equipment.

Customer Any person/ entity supplied with electric service under a contract with a Distributor or Supplier.

Demand The Active Power and/or Reactive Power at a given instant or averaged over a specified interval of time, that is actually delivered or is expected to be delivered by an electrical Equipment or supply System. It is expressed in Watts (W) and/or VARs and multiples thereof.

Demand Control The reduction in Demand for the control of the Frequency when the Grid is in an Emergency State. This includes Automatic Load Shedding, Manual Load Shedding, demand reduction upon instruction by ZETCO, demand disconnection initiated by Users and Voluntary Load Curtailment.

Demand Forecast The projected Demand and Active Energy related to a Connection Point in the Grid.

Derogation of the Grid A condition resulting from a User Development or a Grid expansion project that has a Material Effect on the Grid or the System of other Users and which can be verified through Grid Impact Studies.

Detailed Planning Data Additional data, which the Grid Owner requires, for the conduct of a more accurate Grid planning study

Dispatch The process of issuing direct instructions to the electric power industry participants by the ZETCO to achieve an economic operation while maintaining Power Quality, Stability, and the Reliability and Security of the Grid.

Dispatch Instruction An instruction by **ZETCO Controller** to generators to dispatch generation and to ZEDC to regulate withdrawal in accordance with the Scheduling & Dispatch procedure.

Disconnection The opening of an electrical circuit to isolate an electrical System or Equipment from a power source.

Dispatch The process of apportioning the total Demand of the Grid through the issuance of Dispatch Instructions to the Scheduled Generating Units and the Generating Units providing Ancillary Services in order to achieve the operational requirements of balancing Demand with generation that will ensure the Security of the Grid.

Dispatch Instruction Refers to the instruction issued by ZETCO to the Generators with Scheduled Generating Units and the Generators whose Generating Units will provide Ancillary Services to implement the final Generation Schedule in real time.

Distribution Code The set of rules, requirements, procedures, and standards governing ZEDC and Users of Distribution System in the operation, maintenance and development of the Distribution System. It also defines and establishes the relationship of the Distribution System with the facilities or installations of the

parties connected thereto.

Distribution of Electricity The conveyance of electric power by a Distribution Utility through its Distribution System.

Distribution System The system of electric lines and electrical equipment at voltage levels of 88 kV and 132 kV in Harare and Bulawayo and 33 kV and lower in other areas.

Dynamic Instability A condition that occurs when small undamped oscillations begin without any apparent cause because the Grid is operating too close to an unstable condition.

Earth Fault Factor The ratio of the highest RMS phase-to-ground power Frequency voltage on a sound phase, at a selected location, during a fault to ground affecting one or more phases, to the RMS phase-to-ground power Frequency voltage that would be obtained at the selected location with the fault removed.

Electrical Diagram A schematic representation, using standard electrical symbols, which shows the connection of Equipment or power System Components to each other or to external circuits.

Electricity Act A gazetted act of parliament detailing the power sector setup and obligations.

Electricity Supply System The combination of the Transmission System, distribution system and power stations.

Embedded Generating Plant A Generating Plant that is connected to a Distribution System or the System of any User and has no direct connection to the Grid.

Embedded Generating Unit A Generating unit within an Embedded Generating Plant.

Embedded Generator A person or entity that generates electricity using an Embedded Generating Plant.

End- User A person or entity that requires the supply and delivery of electricity for its own use.

Equipment All apparatus, machines, conductors, etc. used as part of, or in

connection with, an electrical installation.

Equipment Earthing This is the connecting to earth of the non-current carrying metal parts. These include the motor body, switchgear structure, transformer core and tank, sheaths of cables and body of all portable equipment.

Equipment Identification The System of numbering or nomenclature for the identification of Equipment at the Connection Points in the Grid.

Event An unscheduled or unplanned occurrence of an abrupt change or disturbance in a power System due to fault, Equipment Outage, or Adverse Weather Condition.

Fault Clearance Time The time interval from fault inception until the end of the arc extinction by the Circuit Breaker.

Fault Level The expected current, expressed in kA that will flow into a short circuit at a specified point in the Grid or System.

Fixed Asset Boundary Document A document containing information and which defines the operational responsibilities for the Equipment at the Connection Point.

Flicker A small change in line voltage, which causes a perceptible change in the intensity of electric lights. In some situations people can detect sags as low as a third of a volt.

Forced Outage An Outage that results from emergency conditions directly associated with a Component, requiring that it be taken out of service immediately, either automatically or as soon as switching operations can be performed. Also, an Outage caused by human error or the improper operation of Equipment.

Frequency The number of complete cycles of a sinusoidal current or voltage per unit time, usually measured in cycles per second or Hertz

Frequency Control A strategy used by ZETCO to maintain the Frequency of the Grid within the limits prescribed by the Grid Code by the timely use of Frequency Regulating Reserve, Contingency Reserve, and Demand Control.

Frequency Regulating Reserve Refers to a Generating Unit that assists in Frequency Control by providing automatic Primary and/or Secondary Frequency response.

Frequency Variation The deviation of the fundamental System Frequency from its nominal value.

Generating Plant A facility, consisting of one or more Generating Units, where electric Energy is produced from some other form of Energy by means of a suitable apparatus.

Generating Unit A conversion apparatus including auxiliaries and associated Equipment, functioning as a single unit, which is used to produce electric Energy from some other form of Energy.

Generation Company Any person or entity authorized by the ZERC to operate a facility used in the Generation of Electricity.

Generation of Electricity The production of electricity by a Generation Company.

Generation Schedule Refers to the schedule that indicates the hourly output of the Scheduled Generating Units and the list of Generating Units

Generation Scheduling and Dispatch Parameters Refers to the technical data pertaining to the Scheduled Generating Units, which are taken into account in the preparation of the Generation Schedule. Generator.

Grid The high voltage backbone System of interconnected transmission and subtransmission lines, substations, and related facilities for the purpose of conveyance of bulk power. Also known as the Transmission and Sub Transmission System.

Grid Code The set of rules, requirements, procedures, and standards to ensure the safe, reliable, secured and efficient operation, maintenance, and development of the high voltage backbone Transmission System and its related facilities.

Grid Contingencies Abnormal operating conditions brought about by tripping of generating units, transmission lines, transformers or abrupt load changes or by a combination of the above leading to abnormal voltage and/or frequency excursions and/or overloading of network equipment.

Grid Disturbance Grid Disturbance is the situation where disintegration and collapse of grid either in part or full take place in an unplanned and abrupt manner, affecting the power supply in a large area of the region.

Grid Impact Studies A set of technical studies which are used to assess the possible effects of a proposed expansion, reinforcement, or modification of the Grid or a User Development and to evaluate Significant Incidents.

Grid Owner The party that owns the high voltage backbone Transmission System and is responsible for maintaining adequate Grid capacity in accordance with the provisions of the Grid Code.

Grid User Any person and/or entity connected directly to the ZETCO Grid, who shall comply with the provision of this Grid Code

Grounding A conducting connection by which an electrical circuit or Equipment is connected to earth or to some conducting body of relatively large extent that serves as ground.

Harmonics Sinusoidal voltages and currents having frequencies that are integral multiples of the fundamental frequency

High Voltage (HV) Any voltage level exceeding 0.65kV.

IEC Standard The international standard for electro-technical Equipment approved and published by the International Electrotechnical Commission (IEC).

Independent Power Producer (IPP) Independent Power Producer being a power station within the ZESA control area, owned by a generator who is not part of ZPC.

Interconnections Electric lines and electrical equipment used for the transmission of electricity between the Zimbabwe Transmission System and the Transmission System of another country.

Interconnected Transmission System The combination of HV electric lines and electrical equipment directly linked with ZETCO Transmission System and owned or operated by ZPC, ZEDC, ESKOM, EDM, ZESCO and BPC.

Interruption The loss of service to a Customer or a group of Customers or other facilities

Interruption Duration The period from the initiation of an Interruption up to the time when electric service is restored.

Island Grid A Generating Plant or a group of Generating Plants and its associated load, which is isolated from the rest of the Grid but is capable of

generating and maintaining a stable supply of electricity to the Customers within the isolated area.

Isolation The electrical separation of a part or Component from the rest of the electrical System to ensure safety when that part or Component is to be maintained or when electric service is not required.

Limitation of Access Safety documentation to facilitate work in generation, switching or substation plant, defining limits of the area within which work is to be performed.

Live Line Permit to Work (LLPW) A safety document to facilitate work on live lines

Load Crash Sudden or rapid reduction of electrical load connected to a system that could be caused due to tripping of major transmission line(s), feeder(s), power transformer(s) or natural causes like rain etc.

Load Factor The ratio of the total Energy delivered during a given period to the product of the maximum Demand and the number of hours during the same period.

Load Reduction The condition in which a Scheduled Generating Unit has reduced or is not delivering electrical power to the System to which it is synchronized.

Local Safety Instructions A set of instructions regarding the Safety Precautions on HV or EHV Equipment to ensure the safety of personnel carrying out work or testing on the Grid or the User System.

Loss of Load Probability (LOLP) The expected number of days in a specified period in which the daily peak Demand will exceed the available generating capacity

Main Distribution Frame (MDF) An interface panel for process signals

Maximum Continuous Rating (MCR) The normal rated full load MW output capacity of a generating unit, which can be sustained on a continuous basis under specified conditions.

Manual Load Shedding The process of manually and deliberately removing pre-selected Loads from a power System, in response to an abnormal condition, and in order to maintain the integrity of the System.

National Control Centre (NCC) The **ZETCO**'s control room for 24 hour real time power System monitoring and control for the purpose of managing the operation of the power System and co-ordination of generation and consumption.

Negative Sequence Unbalance Factor The ratio of the magnitude of the negative sequence component of the voltages to the magnitude of the positive sequence component of the voltages, expressed in percent.

Power Swing Variation in power, which occur, when the voltages of generators at different points of a power system slip relative to each other.

Outage The state of a Component when it is not available to perform its intended function due to some event directly associated with that Component. An Outage may or may not cause an Interruption of service to Customers.

Outage Duration The period from the initiation of the Outage until the affected Component or its replacement becomes available to perform its intended function.

Over Voltage A long duration RMS voltage variation at least 10 percent greater than the nominal voltage for a period of time greater than one minute.

Planned Outage An outage of power station equipment or transmission facility that has been planned and agreed on in advance.

Peak Period That period in a day when electrical demand is at it's highest.

Project Planning Data The data pertaining to a User Development once the offer for a Connection Agreement or an Amended Connection Agreement is accepted.

PTW (Permit to Work) Safety documentation issued to facilitate work on dead (de-energised) and isolated equipment.

Point of Isolation The point on the Grid or the User System at which Isolation can be established for safety purposes.

Power Factor The ratio of Active Power to Apparent Power.

Power Line Carrier (PLC) A communication Equipment used for transmitting data signals through the use of power transmission lines.

Power Purchase Agreement (PPA) The commercial agreement between a **Generator** and **ZETCO** in which, subject to certain conditions, **ZETCO** agrees to purchase the electrical output of the generating unit and the generator agrees to provide services from this Unit.

Power Supply Agreement The commercial agreement between the **ZETCO** and other Grid Users for the supply of electric power.

Power Station An installation of one or more generating units owned and/or operated by the same generation company.

Power System Plant and equipment on the generation, transmission and distribution networks.

PowerTel Subsidiary Company of ZESA Holdings (Pvt) Ltd responsible for Telecommunication Services

Preliminary Project Planning Data The data relating to a proposed User development at the time the User applies for a Connection Agreement or an Amended Connection Agreement.

Reactive Power The component of electrical power representing the alternating exchange of stored Energy (inductive or capacitive) between sources and loads or between two systems, measured in VAR or multiples thereof. For AC circuits or systems, it is the product of the RMS value of the voltage and the RMS value of the quadrature component of the alternating current. In a three-phase system, it is the sum of the Reactive Power of the individual phases.

REA Rural Electrification Agency

Reliability The probability that a System or Component will perform a required task or mission for a specified time in a specified environment. It is the ability of a power System to continuously provide service to its Customers.

Remote Terminal Unit (RTU) Tele-control equipment installed at a remote location to gather process information and controls the process as directed by the central system.

Resistance Earthing This is the connection of the neutral point to earth through a resistor.

Resonant Earthing This is the connection to earth through a reactance of such a value that power frequency current in the neutral to ground connection is

almost equal and opposite to power frequency capacitance current between un faulted line and earth.

Root Mean Square (**RMS Voltage or RMS Current) -** The AC value that produces the same heating effect in a resistor, as would a DC value of the same magnitude.

Safety Precautions Refers to the Isolation and Grounding of HV or EHV Equipment when work or testing is to be done on the Grid or User System.

Safety Rules The rules that seek to safeguard personnel working on the Grid (or User System) from the hazards arising from the Equipment or the Grid (or User System).

Sanction for Test Safety documentation to facilitate testing of the high voltage plant and equipment

Security The continuous operation of a power System in the Normal State, ensuring safe and adequate supply of power to End-Users, even when some parts or Components of the System are on Outage.

Senior Authorised Person (SAP) A competent person appointed in writing by ZETCO to carry out work and all forms of switching on the ZETCO Grid in accordance with his certificate of authorisation.

Short- term Flicker Severity Index (P_{st}) A measure of visual severity of flicker derived from a time series output of a flicker meter over a ten-minute period

Shut Down The condition of a Generating Unit where it is at rest or on barring gear isolated from grid or transmission facility, which is at rest or isolated from Grid.

Single Outage Contingency An Event caused by the failure of one Component of the Grid including a Generating Unit, transmission line, or a transformer.

Site Refers to a substation or switchyard in the Grid or the User System where the Connection Point is situated.

Spinning Reserve Unused generating capacity, which is synchronised to the System and is ready to instantaneously provide increased generation at short notice in response to Frequency drop.

Southern Africa Power Pool (SAPP) A regional power network in Southern Africa created with the primary aim of providing reliable and economical

electricity supply to the consumers of each of the SAPP members, consistent with the reasonable utilisation of natural resources and the effect on the environment through regional interconnection and harmonisation of operational procedures.

Substation Control System (SCS) The combination of transducers, communication links and data processing systems which provides information to the substation on the operational state of the substation equipment.

Supervisory Control and Data Acquisition (SCADA) The combination of transducers, RTU, communication links and data processing systems which provides information to the NCC and or SCS on the operational state of the power system.

Supplier Any person or entity authorized by the ZERC to sell, broker, market, or aggregate electricity to the End-users.

Synchronised The state when connected Generating Units and/or interconnected AC Systems operate at the same frequency and where the phase angle displacements between their voltages vary about a stable operating point.

System Refers to the Grid or Distribution System or any User System. Also a group of Components connected or associated in a fixed configuration to perform a specified function

System Average Interruption Duration Index (SAIDI) The average forced sustained interruption duration per customer served per year (measured in minutes)

System Average Interruption Frequency Index (SAIFI) The average number of forced sustained interruptions experienced per customer served per year (measured in outages).

System Earthing This is the intentional connection of neutral point to ground so that is the neutral point is earthed, the phase to ground voltages under Earth Fault conditions do not rise to high value.

System Loss The total Energy injected into the Grid (or the Distribution System) minus the total Energy delivered to Distributors and End-Users. In the Grid Code, it is the Energy injected into the Grid by Generating Plants, plus (or minus) the Energy transported through Grid interconnections minus the total Energy delivered to Distributors and End-Users. In the Distribution Code, it is the Energy received from the Grid plus internally generated Energy by Embedded Generating Plants, plus (or minus) the Energy transported by other

Distributors minus the total Energy delivered to End-Users.

System Test The set of tests, which involve simulating conditions or the controlled application of unusual or extreme conditions that may have an impact on the Grid or the User System.

System Test Coordinator A person who is appointed as the chairman of the System Test Group.

System Test Group A group established for the purpose of coordinating the System Test to be carried out on the Grid or the User System.
System Test Procedure A procedure that specifies the switching sequence and proposed timing of the switching sequence, including other activities deemed necessary and appropriate by the System Test Group in carrying out the System Test.

System Test Proponent Refers to the ZETCO or the User who plans to undertake a
System Test and who submits a System Test Request to ZETCO.

System Test Program A program prepared by the System Test Group, which contains the plan for carrying out the System Test, the System Test Procedure, including the manner in which the System Test is to be monitored, the allocation of costs among the affected parties, and other matters that the System Test Group had deemed appropriate and necessary.

System Test Report A report prepared by the Test Proponent at the conclusion of a System Test for submission to ZETCO (if it is not the System Test Proponent), the affected Users, and the members of the System Test Group.

System Test Request A notice submitted by the System Test Proponent to ZETCO indicating the purpose, nature, and procedures for carrying out the proposed System Test.

Synchronised The condition where an incoming generating unit or System is connected to another System so that the voltage, frequencies and phase relationships of that generating unit or System, as the case may be, and the System to which it is connected are identical.

Target Clearance Time The time between relay pick up time and the time the fault is cleared

Technical Loss The component of System Loss that is inherent in the physical delivery of electric Energy. It includes conductor loss, transformer core loss,

and technical errors in meters.

Tele- protection The use of telecommunication channels to operate protection relays through command signals, so as to enable the relays to selectively isolate faults within the shortest possible time and independent of fault location and system conditions.

Teleprotection Security The ability to prevent interference and or noise from generating a trip command at the receiving end when such a command has not been transmitted.

Teleprotection Dependability The ability to issue a valid command at the receiving end in the presence of interference and or noise when such command has been transmitted.

Teleprotection Transmission Time The time elapsed between the moment of change of state at the transmitter command input and the moment of change of state at the receiver command output.

Test and Commissioning Putting into service a System or Equipment that has passed all required tests to show that the System or Equipment was erected and connected in the proper manner and can be expected to work satisfactorily.

Total Demand Distortion (TDD) The ratio of the root-mean-square value of the harmonic content to the root-mean-square value of the rated or maximum demand fundamental quantity, expressed in percent.

Total Harmonic Distortion (THD) The ratio of the root-mean-square value of the harmonic content to the root-mean-square value of the fundamental quantity, expressed in percent.

Total System Blackout The condition when all generation in the Grid has ceased, the entire System has Shutdown, and the ZETCO must implement a Black Start to restore the Grid to its Normal State.

Transformer An electrical device or Equipment that converts voltage and current from one level to another.

Transient A very brief excursion from nominal voltage with durations of a microsecond (millionths of a second) to several hundred microseconds. Transients are classified as impulsive or oscillatory.

Transient Instability A condition that occurs when undamped oscillations between parts of the Grid result in Grid separation. Such Grid disturbances may occur after a fault and the loss of Generating Units and/or transmission lines.

Transient Voltages High-frequency Overvoltages caused by lightning, switching of capacitor banks or cables, current chopping, arcing ground faults, ferroresonance, and other related phenomena.

Trough Period That period in a day when electrical demand is at it's lowest.

Unconstrained Generation Schedule The Generation Schedule without considering any operational constraints such as the Grid constraints, changes in Generating Unit Declared Data and parameters, and changes in forecasted data.

Underfrequency Relay (UFR). An electrical relay that operates when the System Frequency decreases to a preset value.

Under Voltage A long duration RMS voltage variation at least 10 percent below the normal (nominal) voltage for a period of time greater than one minute.

Voltage Sag - A decrease of 10 to 90% in the RMS voltage at the power frequency for durations of one-half cycle to 1 minute

Voltage Swell - A temporary increase in the RMS value of voltage of more than 10% at the power frequency, for durations from one-half cycle to 1 minute.

User A person or entity that uses the Grid or Distribution System and related facilities. Also, a person or entity to whom the Grid Code or Distribution Code applies.

User System Refers to a System owned or operated by a User of the Grid or Distribution System.

Visitor's Live Line Enclosure Permit (VLEP) A safety document signed by visitors acknowledging the dangers of entering a live line enclosure and indemnifying ZETCO against injury, whilst they are in the live enclosure.

Voltage The electromotive force or electric potential difference between two points, which causes the flow of electric current in an electric circuit.

Voltage Control The strategy used by ZETCO, Distributors, or User to maintain the voltage of the Grid, Distribution System, or the User System within the limits prescribed by the Grid Code or the Distribution Code.

Voltage Fluctuation The systematic variation of the voltage envelope or random amplitude changes where the RMS values of voltage is between 90% and 100%

Voltage Instability A condition that results in Grid voltages that is below the level where voltage control Equipment can return them to the normal level. In many cases, the problem is compounded by excessive Reactive Power loss.

Voltage Variation The deviation of the root-mean-square (RMS) value of the voltage from its nominal value, expressed in percent.

Wheeling Charge Refers to the tariff paid for the conveyance of electric Power and Energy through the Grid.

ZEDC Zimbabwe Electricity Distribution Company

ZERC Zimbabwe Electricity Regulatory Commission

ZETCO Zimbabwe Electricity Transmission Company

ZPC Zimbabwe Power Company.

SECTION 1
GOVERNANCE OF THE CODE

1.1 Introduction

Under the terms of the Electricity Act Chapter 13:19 4/2002 the Transmission and Bulk Supply Licensee (ZETCO) is required to implement and ensure compliance to the Grid Code and to periodically review the same and its implementation. Such review shall be subject to approval by ZERC.

1.2 Objective

The objective of this Code is to define the method of managing the Grid Code, submitting and pursuing of any proposed changes to the Grid Code and the responsibility of all Users to effect that change.

1.3 Responsibilities

ZETCO will be responsible for managing and servicing the Grid Code, for discharging its obligations under the License. In this regard, ZETCO shall establish the Grid Code Review Panel and service the requirements of such a Panel.

1.4 Grid Code Review Panel

The Panel shall be chaired by ZETCO and shall consist of the following members:

- Chairman to be nominated by ZETCO
- Member Secretary to be nominated by ZETCO
- One Member from ZPC
- One Member from ZEDC
- One member from ZERC
- One Member from each licensed generator connected to the Grid
- Two Members from large users directly connected to the Grid
- One Member appointed by IPPs and Embedded Generators

Members of the Grid Code Review Panel shall possess relevant technical skills and shall be subject to approval by ZERC. ZERC shall be immediately informed of changes in the composition of the Grid Code Review Panel and shall approve such changes.

For continuity purposes, membership of individuals from above entities shall be permanent and any changes of member representation by entities shall be communicated in writing to ZERC within thirty (30) days.

ZETCO shall provide the secretarial functions of the Grid Code Review Panel. In this regard, ZETCO shall designate an appropriate official to coordinate the activities of the Grid Code Review Panel to ensure compliance to the Grid Code, its revisions and amendments. Zimbabwe Electricity Regulation Commission (ZERC) shall approve the Grid Code and all the amendments and ensure compliance.

1.5 Standing Committees to deal with specific issues

The Grid Code Review Panel can at its discretion form standing committees to deliberate and recommend on specific issues.

The Grid Code Review Panel, at their discretion, shall invite at their meetings, Chairmen of each of the Standing Committees concerned with particular items on their Agendas. The Chairman of a Standing Committee may delegate a representative from the Standing Committee to take part in the discussion.

The Panel, at their discretion, may invite representatives from Consultants and/or any other Organization such as Government Departments, Local Authorities, Railways, Telecommunications, Standard Association of Zimbabwe, Financing Institutions or academic / technical institutions, to attend the Panel Meeting depending on the Agenda. Such invited members can express or offer advice on the matter under consideration but some act as observers in the final determination.

1.6 Grid Code Review Panel Rules

The rules to be followed by the Panel in conducting its business shall be formulated by the Panel itself and shall be approved by ZERC. The Panel will meet at least once in three months.

No revision or modification of the Grid Code shall be made without knowledge of the **Grid Code Review Panel** and ZERC approval.

I n an unusual situation where normal day-to-day operation is not possible without revision of some clauses of the Grid Code, a provisional revision may be implemented before approval of ZERC is received, but only after discussion by the Grid Code Review Panel through a Meeting convened on

emergency basis. ZERC should promptly be intimated about the provisional revision in writing and approve the revisions within fourteen (14) days from the date of notification by the Grid Code Review Panel.

ZERC may issue directions requiring ZETCO to revise the Grid Code in such a manner as may be specified in those directions, and ZETCO shall promptly comply with any such directions through the Grid Code Review Panel.

1.7 Functions of the Grid Code Review Panel

The functions of the Panel are as follows:

1. To keep the Grid Code and its workings under continuous scrutiny and review.
2. To analyse any major Grid disturbances soon after the occurrence as recommended by ZETCO or any other user, and evolve any consequent revision to the Grid Code.
3. To consider all requests for amendment to the Grid Code which are proposed by the Users.
4. To publish recommendations for changes to the Grid Code together with the reasons for the changes and any objections, if applicable.
5. To issue guidance on the interpretations and implementation of the Grid Code
6. To examine problems raised by Users.

ZETCO may hold sub-meetings with a User to discuss individual requirements and with a group of Users to prepare proposals for the Panel meeting.

1.8 Grid Code Review and Revisions Procedures

The Member Secretary shall present all proposed revisions of the Grid Code to the Review Panel for its consideration.

ZETCO shall send the following reports to the ZERC at the conclusion of each review meeting of the Panel.

1. A report on the outcome of such review.
2. Any proposed revisions to the Grid Code as ZETCO reasonably thinks necessary for achievement of the objectives referred to in the relevant paragraph of the Transmission & Bulk Supply License.

3. All written representations or objections from Users raised during the review.

All revisions to the Grid Code shall require approval of ZERC. ZETCO shall publish revisions to the Grid Code, once approved by the ZERC.

Every change from the previous Version shall be clearly marked in the margin. In addition, a revision sheet shall be placed at the front of the Revised Version noting the number of every changed sub-section, together with a brief statement of change.

ZETCO shall keep an up-to-date list of the recipients and locations of all serviced copies of the Grid Code.

1.9 Disputes

The Grid Code Review Panel shall handle disputes regarding interpretation of the Grid Code Code. If one or both parties are not satisfied with the ruling of the Panel the matter shall be referred to ZERC whose decision is final.

1.9.1 Dispute pertaining to issues not covered by the Grid Code

Any technical relevant issues not covered by the Grid Code shall be referred to the Grid Code Review Panel for further consideration for inclusion in the Grid Code. The Grid Code Review Panel's ruling on such issues shall be binding. If any party is not satisfied by the ruling of the Grid Code Review Panel, the matter shall be referred to ZERC. The decision of ZERC shall be final and binding.

1.9.2 Continuity of Functioning of Grid Users

After a dispute arises between entities, the matter should immediately be referred to the Grid Code Review Panel who should make provisional working arrangements that shall be implemented till a valid ruling is issued according to Section 1.9.2 above. The objective of this procedure is to ensure that no dispute shall stall the daily operations of any Grid User .

1.9.3 Unforeseen Circumstances

In situations not addressed by any clause of the Grid Code, ZETCO shall convene an emergency meeting with all affected Grid Users to formulate a solution and the actions to be taken in the circumstance by the Grid Users . If no agreement can be reached, ZETCO shall provisionally

determine the action to be taken after giving consideration to the views expressed by other Users.

ZETCO shall, as soon as possible, but not later than fourteen days, refer the matter to the Grid Code Review Panel whose decision shall prevail over the provisional determination of ZETCO. If a Grid User appeals to ZERC over the decision of the Panel, the decision of ZERC shall supersede the decision of the Panel.

The normal operations of any User should never be disrupted by any situation or dispute. The majority decision of the meeting of Grid Users or the considered determination of ZETCO shall be implemented unless and until the Grid Code Review Panel issues a different ruling; and the ruling of the Panel shall be in force unless and until a different decision is issued by ZERC (if the issue is referred to ZERC). The decision of ZERC is ultimate and shall be implemented by all Grid Users

SECTION 2
GRID CONNECTION CODE

2.1 Introduction

This Grid Code is for the protection of the Transmission System and Users' Plant and Apparatus directly connected to the Transmission System. In order to maintain stable and secure operation of the Transmission System for the benefit of all Users, it is necessary to require certain minimum technical, design and operational criteria to be met by Users' Plant and Apparatus. The Grid Connection Requirements establish certain principles and standards relating to method of connection, technical standards, performance standards, and data requirements. Connection Point. In addition to the Connection Requirements, there are Connection Agreements, which are bilateral between ZETCO and each user and which contain the detail specific to each User's connection to the Transmission System Grid. Such agreements between the User and ZETCO shall comply with the Grid Code.

2.1.1 Purpose

The purpose of the Grid connection requirements is:

a) To specify the technical, design, and operational criteria at the User's Connection Point

b) To ensure that basic rules for connection to the Grid or to a User system are fair and non discriminatory for all Users
c) To ensure that any new connection shall not impose any adverse effects on existing Users
d) To ensure that new connections shall not suffer adversely due to existing Users
e) To assist Users in the maintenance of acceptable reliability and quality levels through specification of minimum design and operational criteria.
f) To list and collate data required by ZETCO from all Users and to list data to be provided by ZETCO from each User

2.1.2 Scope of Grid Connection Requirements

The Grid connection requirements shall apply to:

a) ZPC
b) ZETCO
c) ZEDC
d) Any other generator to be connected to ZETCO System
e) Any User currently connected to or intending to be connected to ZETCO System
f) Any other Transmission System within or outside Zimbabwe connected or intending to be connected to ZETCO system
g) Any provider of Ancillary Services to the Transmission System

ZERC shall monitor compliance to all matters covered by this section of the Grid Code and shall design and effect appropriate penalties for enforcing compliance.

2.2 Grid Technical, Design and Operational Criteria

2.2.1 Power Quality Standards

2.2.1.1 ZETCO shall ensure that at any Connection Point in the Grid, the power quality standards specified in Section 3 of this Grid Code are complied with.

2.2.1.2 Users seeking connection to the Grid or modification of any existing connection shall ensure that their equipment can operate reliably and safely within the limits specified in Section 3 of this Grid Code during normal and emergency conditions and can withstand the limits specified under this Section of the Grid Code.

2.2.2 Frequency Variation

2.2.2.1 ZETCO Grid rated frequency shall be 50.0 Hz with a control range within the statutory range of 47.5Hz to 52.5Hz. All loads and generators connected to ZETCO Grid should be able to operate within this range without being affected negatively.

2.2.2.2 In emergency operating conditions the automatic load shedding scheme detailed in Appendix I shall be undertaken according to rules specified in Section 4 of this Grid Code.

2.2.3 Voltage Variations

The Long Duration Voltage Variations at any Connection Point during normal and emergency conditions shall be within the limits specified in Section 3.3.2 of this Grid Code.

2.2.4 Harmonics

The Total Harmonic Distortion of the voltage and the Total Demand Distortion of the current, at any Connection Point, shall not exceed the limits prescribed in Section 3.3.3 of this Grid Code.

2.2.5 Voltage Unbalance

The maximum Zero and Negative Sequence Unbalance Factors at any Connection Point in the Grid shall not exceed the limits specified in Section 3.3.4 of this Grid Code, during normal and emergency operating conditions.

2.2.6 Voltage Fluctuation and Flicker Severity

The Voltage Fluctuation at any Connection Point with a fluctuating Demand shall not exceed the limits specified in Section 3.3.5 of this Grid Code, during normal and emergency operation conditions.

2.2.7 Transient Voltage Variations

The Grid and the User System shall be designed and operated to include devices that will mitigate the effects of transient over voltages on the Grid and the User System. ZETCO and the User shall take into account the effect of electrical transients when specifying the insulation of their electrical Equipment.

2.2.8 Grounding Requirements

The Grid shall be effectively grounded with an Earth Fault Factor of less than 1.4. for all voltage levels connected to the Grid.

2.2.9 Equipment Standards

All Equipment at the Connection Point shall comply with the requirements of the IEC Standards or their equivalent Zimbabwe national standards.

2.3 Requirements for Grid Connection or Modification

Any user seeking to establish new or modified arrangements for connection to and/or use of the Transmission System shall follow the procedures laid out below.

2.3.1 Connection Agreement

2.3.1.1 Any User seeking use of the Transmission System must submit an Application for connection to ZETCO using the application forms available from ZETCO.

2.3.1.2 The connection agreement shall include the provisions for the submission of information reports, safety rules, test and commissioning programs, electrical diagrams, statement of readiness to connect and any other requirements that may from time to time be specified by ZETCO and/or ZERC.

2.3.2 Amended Connection Agreement

2.3.2.1 Any User seeking a modification of any existing connection to the Grid shall secure the required amended connection agreement with ZETCO prior to the actual modification of the existing connection to the Grid.

2.3.2.2 The amended connection agreement shall include provisions for the submission of additional information and reports required by ZETCO and other requirements prescribed by the ZERC

2.3.3 Grid Impact Studies

2.3.3.1 ZETCO shall develop and maintain a set of required technical planning studies for evaluating the impact on the Grid of any proposed connection or modification to an existing connection. These planning studies shall be completed within 30 (thirty) calendar days.

2.3.3.2 ZETCO shall specify which of the planning studies described in Section 4 of this Grid Code will be carried out to evaluate the impact to the Grid of the proposed User Development.

2.3.3.3 The User shall indicate whether it wishes ZETCO to undertake additional technical studies. The User shall shoulder the cost of the additional technical studies.

2.3.3.4 Any User applying for connection or a modification of an existing connection to the Grid shall take all necessary measures to ensure that the proposed User Development will not result in the Derogations of the Grid. ZETCO may disapprove an application for connection or a modification to an existing connection, if the Grid Impact Studies show that the proposed User Development will result in the Derogation of the Grid.

2.3.3.5 To enable ZETCO to carry out the necessary detailed Grid Impact Studies, the User is required to provide all the necessary Detailed Planning Data, as prescribed by ZETCO from time to time, prior to any connection

2.3.3.6 ZETCO shall maintain an up to date fault level database that should be made available on request by Grid Users. ZETCO shall inform the Grid User, if fault levels at a Connection Point are likely to impact adversely on the User's Equipment connected to the Grid.

2.3.4 Procedures for Application for Connection or Modification

2.3.4.1 ZETCO shall establish the procedures for the processing of applications for connection or modification of an existing connection to the Grid.

2.3.4.2 The User shall submit to ZETCO the completed application form for connection or modification of an existing connection to the Grid. The application form shall include the following information:

(a) A description of the proposed connection or modification to an existing connection, which shall comprise the User Development at the Connection Point;
(b) The relevant Standard Planning Data listed in Section 4 of this

Grid Code and any other relevant data as prescribed by ZETCO from time to time.

(c) The Completion Date of the proposed User Development.

2.3.4.3 The User shall submit the planning data in three (3) stages, according to their degree of commitment and data requirement as follows:

a) Preliminary Project Planning Data;
b) Committed Project Planning Data; and
c) Connected Project Planning Data.

2.3.5 Processing of Application

2.3.5.1 ZETCO shall process the application for connection or modification to an existing connection within 30 (thirty) calendar days from the submission of the completed application form.

2.3.5.2 After evaluating the application submitted by the User, ZETCO shall inform the User whether the proposed User Development is acceptable or not.

2.3.5.3 If the application of the User is acceptable, ZETCO and the User shall sign a Connection Agreement or an Amended Connection Agreement, as the case may be.

2.3.5.4 If the application of the User is not acceptable, ZETCO shall notify the User why its application is not acceptable. ZETCO shall include in its notification a proposal on how the User's application will be acceptable to ZETCO.

2.3.5.5 The User shall accept the proposal of ZETCO within 90 (ninety) calendar days after which the proposal automatically lapses.

2.3.5.6 The acceptance by the User of ZETCO's proposal shall lead to the signing of a Connection Agreement or an Amended Connection Agreement.

2.3.5.7 If ZETCO and the User cannot reach an agreement on the proposed connection or modification to an existing connection, ZETCO or the User may bring the matter before the ZERC for resolution.

2.3.6 Submittals Prior to the Commissioning Date

2.3.6.1 The following shall be submitted by the User prior to the commissioning date, pursuant to the terms and conditions and schedules specified in the Connection Agreement:

a) Specifications of major Equipment not included in the Standard Planning Data and Detailed Planning Data;
b) Details of the protection arrangements and settings referred to in Section 7 of this Grid Code for Generating Units, Distributors and other Grid Users;
c) Information to enable ZETCO to prepare the Fixed Asset Boundary Document including the name(s) provisions of Article 2.6 of this Section
d) Electrical Diagrams of the User's Equipment at the Connection Point as described in Article 2.7 of this Section;
e) Information that will enable ZETCO to prepare the Connection Point Drawings, referred to in Article 2.8 of this Section;
f) Copies of all Safety Rules and Local Safety Instructions applicable to the User's Equipment and a list of Safety Coordinators
g) A list of the names and telephone numbers of authorized representatives, including the confirmation that they are fully authorized to make binding decisions on behalf of the User.
h) Proposed Maintenance Program; and
i) Test and Commissioning procedures for the Connection Point and the User Development.

2.3.7 Commissioning of Equipment and Physical Connection to the Grid

2.3.7.1 Upon completion of the User Development, including work at the Connection Point, the Equipment at the Connection Point and the User Development shall be subjected to the Test and Commissioning procedures specified in Section 7 of this Grid Code.

2.3.7.2 The User shall then submit to ZETCO a statement of readiness to connect, which shall include the Test and Commissioning reports.

2.3.7.3 Upon acceptance of the User's statement of readiness to connect, ZETCO shall, within 15 (fifteen) working days, issue a certificate of approval to connect.

2.3.7.4 The physical connection to the Grid shall be made only after the certificate of approval to connect has been issued by ZETCO to the User.

2.4 Requirements For Large Generators

2.4.1 Requirements Relating to the Connection Point

2.4.1.1 The Generator's Equipment shall be connected to the Grid at the voltage level(s) agreed to by ZETCO and the Generator based on Grid Impact Studies.

2.4.1.2 The Connection Point shall be controlled by a circuit breaker that is capable of interrupting the maximum short circuit current at the point of connection as specified by ZETCO.

2.4.1.3 Isolators shall be provided to adequately isolate the circuit breaker for maintenance purposes at the local point.

2.4.2 Generating Unit Power Output

2.4.2.1 The Generating Unit shall be capable of continuously supplying its Active Power output, as specified in the Generator's Declared Data, within the System Frequency range of 52.5 to 47.5 Hz as per statutory requirements.

2.4.2.2 The Generating Unit shall be capable of supplying its Active Power and Reactive Power outputs, as specified in the Generator's Declared Data, within the voltage variations specified in Section 3.3.2 of this Grid Code during normal and emergency operating conditions.

2.4.2.3 The Generating Unit shall be capable of supplying its Active Power output, as specified in the Generator's Declared Data, within the limits of 0.85 Power Factor lagging and 0.98 Power Factor leading at the Generating Unit's terminals, in accordance with its Reactive Power Capability Curve.

2.4.3 Frequency Withstand Capability

2.4.3.1 The generating units should be capable of operating in synchronism when the System frequency momentarily rises to 52.5 Hz or falls to 47.5 Hz.

2.4.3.2 The Generator shall be responsible for protecting its Generating Units against damage for frequency excursions outside the range of 52.5 Hz and 47.5 Hz. The Generator shall provide adequate protection to disconnect the Generating Unit from the Grid, if the frequency is outside limits 52.5Hz and 47.5Hz.

2.4.4 Unbalance Loading Withstand Capability

2.4.4.1 The Generating Unit shall meet the requirements for Voltage Unbalance as specified in Section 3.3.4 of this Grid Code.

2.4.4.2 The Generating Unit shall also be required to withstand without tripping, the unbalance loading during clearance by the Backup Protection of a close-up phase-to-phase fault on the Grid or, in the case of an Embedded Generating Unit, on the User System.

2.4.5 Speed- Governing System

2.4.5.1 The Generating Unit shall be capable of contributing to Frequency Control by continuous regulation of the Active Power supplied to the Grid or to the User System in the case of an Embedded Generating Unit. The Generating Unit shall be fitted with a fast-acting speed-governing system to provide Frequency Control under normal operating conditions. All governors shall have droop settings adjustable between 3% and 6% and should be set at 5% or any such setting as given by ZETCO National Grid Controller.

2.4.5.2 When a Generating Unit becomes isolated from the Grid, the speed - governing System shall provide Frequency Control to the resulting Island Grid. Exemptions from this requirement shall be specified in the Connection Agreement or Amended Connection Agreement.

2.4.6 Excitation Control System

2.4.6.1 The Generating Unit shall be capable of contributing to Voltage Control by continuous regulation of the Reactive Power supplied to the Grid or, in the case of Embedded Generating Unit, to the User System.

2.4.6.2 The Generating Unit shall be fitted with a continuously acting automatic excitation control System to control the terminal voltage without instability over the entire operating range of the Generating Unit.

2.4.6.3 The performance requirements for excitation control facilities, including power System stabilizers, where necessary for System operations shall be specified in the Connection Agreement or Amended Connection Agreement.

2.4.7 Black Start Capability

2.4.7.1 The Grid shall have Black Start capability at a number of strategically located Generating Plants.

2.4.7.2 The Generator shall specify in its application for a Connection Agreement or Amended Connection Agreement if its Generating Unit has a Black Start capability.

2.4.8 Fast Start Capability

The Generator shall specify in its application for a Connection Agreement or Amended Connection Agreement if its Generating Unit has a Fast Start capability.

2.4.9 Protection Arrangements

2.4.9.1 The protection of Generating Units and Equipment and their connection to the Grid shall be designed, coordinated, and tested to achieve the desired level of speed, sensitivity, dependability and selectivity in fault clearing and to minimize the impact of faults on the Grid as specified under Section 7 of this Grid Code.

2.4.9.2 ZETCO and the User shall be solely responsible for the protection System of the electrical equipment and facilities at their respective sides of the Connection Point.

2.4.9.3 The site specific Fault Clearance Time shall be specified in the Connection agreement or Amended Connection Agreement. The general clearance times are for guidance purposes as specified in Section 7 of this Grid Code.

2.4.9.4 Where the Generator's Equipment are connected to the Grid and a circuit breaker is provided by the Generator (or by ZETCO) at the Connection Point to interrupt the fault current at any side of the Connection Point, a circuit breaker fail protection shall also be provided by the Generator (or ZETCO).

2.4.9.5 The circuit breaker fail protection shall be designed to initiate the tripping of all the necessary electrically adjacent circuit breakers and to interrupt the fault current within the next 50 milliseconds, in the event that the primary protection system fails to interrupt the fault current within the prescribed Fault Clearance Time.

2.4.9.6 The Generator shall provide protection against loss of excitation on the Generating Unit.

2.4.9.7 The Generator shall provide protection against pole-slipping on the Generating Unit.

2.4.9.8 The ability of the protection scheme to initiate the successful tripping of the Circuit Breakers that are associated with the faulty Equipment, measured by the System Protection Dependability Index, shall be not less than 99 percent.

2.4.9.9 All Grid Users shall provide adequate space for accommodation of ZETCO's protection equipment, communication equipment and network control equipment.

2.4.10 Transformer Connection and Grounding

2.4.10.1 If the Generator's Equipment is connected to the Grid, the high-voltage side of the transformer shall be connected in Wye, with the neutral available for connection to ground.

2.4.10.2 ZETCO shall specify the connection and grounding requirements for the LV side of the transformer, in accordance with the provisions of Section 7 of this Grid Code.

2.5 REQUIREMENTS FOR DISTRIBUTORS AND OTHER GRID USERS

2.5.1 Requirements Relating to the Connection Point

2.5.1.1 The Distributor's or other Grid User's Equipment shall be connected to the Grid at voltage level(s) agreed to by ZETCO and the Distributor (or other Grid User) based on Grid Impact Studies.

2.5.1.2 The Connection Point shall be controlled by a circuit breaker that is capable of interrupting the maximum short circuit current as specified by ZETCO at the point of connection.

2.5.1.3 Isolators shall also be provided to adequately isolate the circuit breaker for maintenance purposes at the local point.

2.5.2 Protection Arrangements

The protection of the Distributor's or other Grid User's Equipment at the Connection Point shall be designed, coordinated, and tested to achieve the desired level of speed, sensitivity, and selectivity in fault clearing and to minimize the impact of faults on the Grid as per the guidelines in Section 7 of this Grid Code.

2.5.3 Transformer Connection and Grounding

2.5.3.1 If the Distributor's or other Grid User's Equipment are connected to the Grid, the high-voltage side of the transformer shall be connected in Wye, with the neutral available for connection to ground.

2.5.3.2 ZETCO shall specify the connection and grounding requirements for the low-voltage side of the transformer, in accordance with the

provisions of Section 7 of the Grid Code.

2.5.4 Underfrequency Relays for Automatic Load Shedding

2.5.4.1 The Connection Agreement or Amended Connection Agreement shall specify the manner in which Demand, subject to Automatic Load Shedding, will be split into discrete MW blocks to be actuated by Underfrequency Relays.

2.5.4.2 The voltage supply to the Underfrequency Relays shall be sourced from the primary System at the supply point to ensure that the input Frequency to the Underfrequency Relay is the same as that of the primary System.

2.5.4.3 The tripping facility shall be designed and coordinated in accordance with the reliability levels specified by ZETCO. The overall dependability shall not be lower than 99%.

2.6 COMMUNICATION AND SCADA EQUIPMENT REQUIREMENTS

2.6.1 Communication System for Monitoring and Control

2.6.1.1 A communication System shall be established so that ZETCO and the Users can communicate with one another, as well as exchange data signals for monitoring and controlling the Grid during normal and emergency conditions.

2.6.1.2 ZETCO shall provide the complete communication Equipment required for the monitoring and control of the Connection Point and the Generating Units. A connection fee shall be charged to the user of the Grid as per the connection agreement for the provision of such equipment.

Communication Equipment shall conform to the interface standard and protocol specified by ZETCO. The Generators to be under control shall be specified in the Connection Agreement.

2.6.1.3 ZETCO may use a combination of digital and analogue communication media

2.6.2 SCADA System for Monitoring and Control

2.6.2.1 Overall real time operation and monitoring of the Grid shall be supervised from the National Control Center. The National Control Center shall be manned around the clock.

2.6.2.2 ZETCO shall provide a Remote Terminal Unit (RTU) for interconnection with the National Control Centre, to serve as Telecontrol Equipment for monitoring real-time information and controlling the Equipment at the Connection Point. The costs of such equipment shall be borne by customers as connection fees as per connection agreement.

2.6.2.3 The RTU shall be compatible with the Master Station protocol requirements and modem specifications of ZETCO. In the event that the Master Station is changed, ZETCO shall be responsible for any change needed for the RTU to match the new requirements.

2.6.2.4 ZETCO shall also provide, if applicable, other related Equipment such as transducers, cables, modems, etc. for interconnection with the SCADA System of the Grid. The costs of such equipment shall be borne by customers as connection fees as per connection agreement.

2.7 FIXED ASSET BOUNDARY DOCUMENT REQUIREMENTS

2.7.1 Fixed Asset Boundary Document

2.7.1.1 The Fixed Asset Boundary Documents for any Connection Point shall provide the information and specify the operational responsibilities of ZETCO and the User for the following:

a) HV and EHV Equipment;
b) L V and MV Equipment; and
c) Communications and metering equipment.

2.7.1.2 The Fixed Asset Boundary Document shall show precisely the Connection Point and shall specify the following:

a) Equipment and their ownership;
b) Accountable Managers;
c) Safety Rules and procedures including Local Safety Instructions and the Safety Coordinator(s) or any other persons responsible for safety;
d) Operational procedures and the responsible party for operation and control;
e) Maintenance requirements and the responsible party for undertaking maintenance; and
f) Any agreement pertaining to emergency conditions.

2.7.1.3 The Fixed Asset Boundary Documents shall be available at all times for the use by the operations personnel of ZETCO and the User.

2.7.2 Accountable Managers

2.7.2.1 Prior to the Completion Date specified in the Connection Agreement or Amended Connection Agreement, the User shall submit to ZETCO a list of Accountable Managers who are duly authorized to sign the Fixed Asset Boundary Documents on behalf of the User.

2.7.2.2 Prior to the Completion Date specified in the Connection Agreement or Amended Connection Agreement, ZETCO shall provide to the User the name of the Accountable Manager who shall sign the Fixed Asset Boundary Documents on behalf of ZETCO.

2.7.2.3 Any change to the list of Accountable Managers shall be communicated to the other party at least six (6) weeks before the change becomes effective. If the change was not anticipated, it must be communicated as soon as possible to the other party, with an explanation why the change had to be made.

2.7.2.4 Unless specified otherwise in the Connection Agreement or the Amended Connection Agreement, the construction, Test and Commissioning, control, operation and maintenance of Equipment, accountability, and responsibility shall follow ownership.

2.7.3 Preparation of Fixed Asset Boundary Document

2.7.3.1 ZETCO shall establish the procedure and forms required for the preparation of the Fixed Asset Boundary Documents.

2.7.3.2 The User shall provide the information that will enable ZETCO to prepare the Fixed Asset Boundary Document, in accordance with the schedule specified in the Connection Agreement or Amended Connection Agreement.

2.7.3.3 ZETCO shall prepare a preliminary Fixed Asset Boundary Document for the Connection Point at least two (2) weeks prior to the Commissioning date. The final Fixed Asset Boundary Document shall be produced at most 2 (two) weeks after the final commissioning of the connection point

2.7.3.4 The Fixed Asset Boundary Document for the Equipment at the Connection Point shall include the details of the lines or cables emanating from ZETCO's and the User's sides of the Connection Point.

2.7.3.5 The date of issue and the issue number shall be included in every page

of the Fixed Asset Boundary Document.

2.7.4 Signing and Distribution of Fixed Asset Boundary Document

2.7.4.1 Prior to the signing of the Fixed Asset Boundary Document, ZETCO shall send a copy of the completed Fixed Asset Boundary Document to the User, for any revision or for confirmation of its accuracy.

2.7.4.2 The Accountable Managers designated by ZETCO and the User shall sign the Fixed Asset Boundary Document, after confirming its accuracy.

2.7.4.3 ZETCO shall provide two (2) copies of the Fixed Asset Boundary Document to the User, with a notice indicating the date of issue, the issue number and the implementation date of the Fixed Asset Boundary Document.

2.7.5 Modifications of an Existing Fixed Asset Boundary Document

2.7.5.1 When a User has determined that a Fixed Asset Boundary Document requires modification, it shall inform ZETCO at least eight (8) weeks before implementing the modification. ZETCO shall then prepare a revised Fixed Asset Boundary Document at least six (6) weeks before the implementation date of the modification.

2.7.5.2 When ZETCO has determined that a Fixed Asset Boundary Document requires modification, it shall prepare a revised Fixed Asset Boundary Document at least six (6) weeks prior to the implementation date of the modification.

2.7.5.3 When ZETCO or a User has determined that a Fixed Asset Boundary Document requires modification to reflect an emergency condition, ZETCO or the User, as the case may be, shall immediately notify the other party. ZETCO and the User shall meet to discuss the required modification to the Fixed Asset Boundary Document, and shall decide whether the change is temporary or permanent in nature. Within seven (7) days after the conclusion of the meeting between ZETCO and the User, ZETCO shall provide the User a revised Fixed Asset Boundary Document.

2.7.5.4 The procedure specified in Section 2.6.4 of this Grid Code for signing and distribution shall be applied to the revised Fixed Asset Boundary Document. ZETCO's notice shall indicate the revision(s), the new issue number and the new date of Issue.

2.8 ELECTRICAL DIAGRAM REQUIREMENTS

2.8.1 Responsibilities of ZETCO and Users

2.8.1.1 ZETCO shall specify the procedure and format to be followed in the preparation of the Electrical Diagrams for any Connection Point.

2.8.1.2 The User shall prepare and submit to ZETCO an Electrical Diagram for all the Equipment on the User's side of the Connection Point, in accordance with the schedule specified in the Connection Agreement or Amended Connection Agreement.

2.8.1.3 ZETCO shall provide the User with an Electrical Diagram for all the Equipment on ZETCO's side of the Connection Point, in accordance with the schedule specified in the Connection Agreement or Amended Connection Agreement.

2.8.1.4 If the Connection Point is at the User's Site, the User shall prepare and distribute a composite Electrical Diagram for the entire Connection Point. Otherwise, ZETCO shall prepare and distribute the composite Electrical Diagram for the entire Connection Point.

2.8.2 Preparation of Electrical Diagrams

2.8.2.1 The Electrical Diagrams shall provide an accurate record of the layout and circuit connections, ratings and identification of Equipment, and related apparatus and devices at the Connection Point.

2.8.2.2 If possible, all the Equipment at the Connection Point shall be shown in one Electrical Diagram. When more than one Electrical Diagram is necessary, duplication of identical information shall be minimized. The Electrical Diagrams shall represent, as closely as possible, the physical arrangement of the Equipment and their electrical connections.

2.8.2.3 The current status of the Equipment shall be indicated in the diagram. For example, a decommissioned switch bay shall be labeled "Spare Bay."

2.8.2.4 The title block of the Electrical Diagram shall include the names of authorizing persons together with provisions for the details of revisions, dates, and signatures.

2.8.3 Changes to Electrical Diagrams

2.8.3.1 If ZETCO or a User decides to add new Equipment or change an

existing Equipment Identification, ZETCO or the User, as the case may be, shall provide the other party a revised Electrical Diagram, at least one month prior to the proposed physical addition or change.

2.8.3.2 If the modification involves the replacement of existing Equipment, the revised Electrical Diagram shall be provided to the other party in accordance with the schedule specified in the Amended Connection Agreement.

2.8.3.3 The revised Electrical Diagram shall incorporate the new Equipment to be added, the existing Equipment to be replaced or the change in Equipment Identification.

2.8.4 Validity of Electrical Diagrams

2.8.4.1 The composite Electrical Diagram prepared by ZETCO or the User, in accordance with the provisions of Section 5.8.1 of the Grid Code, shall be the Electrical Diagram to be used for all operation and planning activities associated with the Connection Point.

2.8.4.2 If differences arise pertaining the accuracy of the composite Electrical Diagram, a meeting between ZETCO and the User shall be held as soon as possible, to resolve the dispute.

2.9 CONNECTION POINT DRAWING REQUIREMENTS

2.9.1 Responsibilities of ZETCO and Users

2.9.1.1 ZETCO shall specify the procedure and format to be followed in the preparation of the Connection Point Drawing for any Connection Point.

2.9.1.2 The User shall prepare and submit to ZETCO the Connection Point Drawing for the User's side of the Connection Point, in accordance with the schedule specified in the Connection Agreement or Amended Connection Agreement.

2.9.1.3 ZETCO shall provide the User with the Connection Point Drawing for ZETCO's side of the Connection Point, in accordance with the schedule specified in the Connection Agreement or Amended Connection Agreement.

2.9.1.4 If the Connection Point is at the User Site, the User shall prepare and distribute a composite Connection Point Drawing for the entire Connection Point. Otherwise, ZETCO shall prepare and distribute the composite Connection Point Drawing for the entire Connection Point.

2.9.2 Preparation of Connection Point Drawings

2.9.2.1 The Connection Point Drawing shall provide an accurate record of the layout and circuit connections, ratings and identification of Equipment, and related apparatus and devices at the Connection Point.

2.9.2.2 The Connection Point Drawing shall indicate the Equipment layout, common protection, control and auxiliaries. The Connection Point Drawing shall represent, as closely as possible, the physical arrangement of the Equipment and their electrical connections.

2.9.2.3 The title block of the Connection Point Drawing shall include the names of authorized persons together with provision for the details of revisions, dates, and signatures.

2.9.3 Changes to Connection Point Drawings

2.9.3.1 If ZETCO or a User decides to add new Equipment or change an existing Equipment Identification, ZETCO or the User, as the case may be, shall provide the other party a revised Connection Point Drawing, at least one month prior to the proposed addition or change.

2.9.3.2 If the modification involves the replacement of existing Equipment, the revised Connection Point Drawing shall be provided to the other party in accordance with the schedule specified in the Amended Connection Agreement.

2.9.3.3 The revised Connection Point Drawing shall incorporate the new Equipment to be added, the existing Equipment to be replaced, or the change in Equipment Identification.

2.9.3.4 ZETCO and the User shall, if they have agreed to do so in writing, modify their respective copies of the Connection Point Drawings to reflect the change that they have agreed on, in accordance with the schedule specified in the Connection Agreement or Amended Connection Agreement.

2.9.4 Validity of the Connection Point Drawings

2.9.4.1 The composite Connection Point Drawing prepared by ZETCO or the User, in accordance with Section 2.8.1.4 of this Grid Code, shall be the Connection Point Drawing to be used for all operation and planning activities associated with the Connection Point.

2.9.4.2 If differences arise pertaining the accuracy of the composite Connection Point Drawing, a meeting between ZETCO and the User

shall be held as soon as possible, to resolve the dispute.

2.10 GRID DATA REGISTRATION

2.10.1 Data to be Registered

2.10.1.1 The data relating to the Connection Point and the User Development that are submitted by the User to ZETCO shall be registered according to the following data categories:
(a) Forecast Data;
(b) Estimated Equipment Data; and
(c) Registered Equipment Data.

2.10.1.2 The Forecast Data, including Demand and Active Energy, shall contain the User's best estimate of the data being projected for the five (5) succeeding years.

2.10.1.3 The Estimated Equipment Data shall contain the User's best estimate of the values of parameters and information about the Equipment for the five (5) succeeding years.

2.10.1.4 The Registered Equipment Data shall contain validated actual values of parameters and information about the Equipment that are submitted by the User to ZETCO at the connection date. The Registered Equipment Data shall include the Connected Project Planning Data, which shall replace any estimated values of parameters and information about the Equipment previously submitted as Preliminary Project Planning Data and Committed Project Planning Data.

2.10.2 Stages of Data Registration

2.10.2.1 The data relating to the Connection Point and the User Development that are submitted by a User applying for a Connection Agreement or an Amended Connection Agreement shall be registered in three (3) stages and classified accordingly as:
(a) Preliminary Project Planning Data;
(b) Committed Project Planning Data; and
(c) Connected Project Planning Data;

2.10.2.2 The data that is submitted at the time of application for a Connection Agreement or an Amended Connection Agreement shall be considered as Preliminary Project Planning Data. This data shall contain the Standard Planning Data specified and the Detailed Planning Data specified in Section 4.5 of this Grid Code, when required ahead of the schedule specified in the Connection Agreement or Amended

Connection Agreement.

2.10.2.3 Once the Connection Agreement or the Amended Connection Agreement is signed, the Preliminary Project Planning Data shall become the Committed Project Planning Data, which shall be used in evaluating other applications for Grid connection or modification of existing Grid connection and in preparing the Transmission Development Plan.

2.10.2.4 The Estimated Equipment Data shall be updated, confirmed, and replaced with validated actual values of parameters and information about the Equipment at the time of connection, which shall become the Connected Project Planning Data. These data shall be registered in accordance with the categories specified in Section 2.10.1 of this Grid Code and shall be used in evaluating other applications for Grid connection or modification of existing Grid connection and in preparing the Transmission Development Plan.

2.11 Data Forms

ZETCO, in consultation with ZERC shall develop the forms for all data to be submitted in accordance with an application for a Connection Agreement or an Amended Connection Agreement.

2.12 Connected Plant Restrictions

2.12.1 General Principle

Users connected to the Grid can cause power disturbances, which propagate to the power System. If these disturbances are severe, the power System and other users on the System will be adversely affected as described in Section 4.1 of this Grid Code. To ensure System integrity and fairness to all Users restrictions and controls have to be placed on users of the System.

2.12.2 Safety

The term "Safety" refers to safety standards adopted in manufacture, erection stages in choice of location and in installation, operation and maintenance procedures. The term applies both to safety to equipment and safety to persons including safety of general public (in addition to safety of utility staff). The equipment of the Users, including machines, devices, overhead lines, underground cables, transformers, etc., must conform to ZESA Electrical Safety Rules, SAZ Standards and other Statutory instruments such as

Factories and Works Act, regulations and rules that may from time to time be in existence in Zimbabwe. In addition where such rules are not in place IEC standards (IEC 950) shall be used in the interim pending development of national standards.

2.12.3 Insulation

The users' System must be designed with the proper basic insulation level (BIL). Insulation of all components in service must have adequate dielectric strength for the System operating voltages at all times.

2.12.4 Clearances

All overhead lines, equipment and facilities of the User's System connected to the GRID must comply with clearance limits published in the ZESA Electricity Safety Rules.

2.12.5 Earthing

All components of the Users' Systems must be properly earthed as specified by ZETCO from time to time. All individual earth electrodes, earthing pits, and the interconnection arrangements shall be as per standards and shall be properly maintained. The bodies/cases/trucks/enclosures of all items of equipment shall be properly earthed, with the actual earthing arrangements depending on the machine ratings.

Metallic supports of overhead lines and cable sheaths and shields shall also be earthed as appropriate.

2.12.6 Safety Training

Personnel of all entities shall be adequately trained in the correct operating techniques and safety precautions as per the requirements of the ZESA Electrical Safety Rules.

2.12.7 Access by ZETCO

ZETCO and its authorized personnel shall have the right to inspect the plant of any user to ensure conformity to standards and restrictions.

2.12.8 Unintended and Unscheduled back- energisation

The Users shall take adequate precautions to ensure that no part of the Grid is energized by the Users' System from another source of supply unless it is requisitioned in writing by the utility as an exceptional arrangement. The switchgear and controls of the Users' Systems shall be so designed as to prevent back-energisation and the personnel shall be made aware of the need for this precaution.

2.12.9 Site And Equipment Identification

2.12.9.1 Site and Equipment Identification Requirements

2.12.9.1.1 ZETCO shall develop and establish a standard system for Site and Equipment Identification to be used in identifying any Site or Equipment in all Electrical Diagrams, Connection Point Drawings, Grid operations instructions, notices, and other documents.

2.12.9.1.2 The identification for the Site shall include a unique identifier for each substation and switchyard where a Connection Point is located.

2.12.9.1.3 The identification for Equipment shall be unique for each transformer, transmission line, transmission tower or pole, bus, circuit breaker, isolator, earthing switch, capacitor bank, reactor, lightning arrester, and other HV and EHV Equipment at the Connection Point.

2.12.9.2 Site and Equipment Identification Requirements Label

2.12.9.2.1 ZETCO shall develop and establish a standard labelling system, which specifies the dimension, sizes of characters, and colours of labels, to identify the Sites and Equipment.

2.12.9.2.2 ZETCO or the User shall be responsible for the provision and installation of a clear and unambiguous label showing the Site and Equipment Identification at their respective System.

SECTION 3
PERFORMANCE STANDARDS CODE

3 POWER QUALITY STANDARDS

3.1 Introduction

This Section specifies the electrical parameters of performance of the GRID, which affect the performance of connected Users, and other Transmission Systems interconnected to the Transmission Grid.

3.1 Purpose and Scope

- To ensure that the Grid performance meets a minimum standard which is essential for ZETCO and the Users' System and equipment to function properly.
- To enable Users to design their systems and equipment to suit the electrical environment that they operate in
- To enhance the quality standards of ZETCO Electrical System towards standards stipulated in or established under Acts and Rules in the short term and gradually moving towards international standards in the long term.

The Grid performance standards apply to:

a) Zimbabwe Power Company
b) ZETCO
c) ZEDC
d) Any other generator connected to ZETCO System
e) Any user currently connected to or intending to be connected to ZETCO System
f) Any other Transmission System within or outside Zimbabwe connected or intending to be connected to ZETCO System
g) Any provider of Ancillary Services to the Transmission System

ZERC shall monitor compliance to all matters covered by this section of the Grid Code and shall design and effect appropriate penalties for enforcing compliance.

3.3 Power Quality

Power quality shall refer to acceptability of the voltage, including, system frequency during normal operations.

3.3.1 Frequency Variations

Frequency of the Transmission System should be maintained within an acceptable range to ensure proper operation of the System. The nominal frequency shall be 50 Hz. During normal and emergency conditions the following frequency ranges shall apply

Table 3.3.1 Frequency Limits

Statutory limits	
Upper limit:	52.5 Hz
Lower limit	47.5 Hz

3.3.2 Harmonics

Harmonics have many negative effects on the System and connected loads, so they have to be limited to a manageable level. Control of harmonics on ZETCO System is based on voltage harmonic distortion. Harmonics are grouped into three categories: odd triplens (multiples of three), other odd harmonics, and even harmonics, with different severity levels and effects on equipment for each category. Odd harmonics are much more common than even harmonics.

3.3.2.1 Limits

Wherever necessary the harmonics limits shall be calculated and set as per IEC/TR3 61000-3-7 standard as per Table 3.3.2 below.

Table 3.3.2 Maximum Limits of Voltage Harmonic Distortion in HV and EHV Systems

Harmonic Order	Distortion	
	HV	EHV
(Odd, non-triplen)		
5	6.0	2.0
7	5.0	2.0
11	3.5	1.5
13	3.0	1.5
17	2.0	1.0
19	1.5	1.0
23	1.5	1.0
25	1.5	0.7
>25	0.2+1.3x25/n*	0.1+0.6x25/n
(Odd, triplen)		
3	5.0	2.0
9	1.5	1.0
15	0.3	0.3
21	0.3	0.2
>21	0.2	0.2
(Even)		
2	2.0	2.0
4	1.0	2.0
6	0.5	0.5
8	0.5	0.4
10	0.5	0.4
12	0.2	0.2
>12	0.2	0.2
Total Harmonic Distortion	8%	3%

n* harmonic order

3.3.2.2 Control and Measurement

Measurements may be taken at any time by ZETCO at the customer's **Connection Point**. Measurements have to be taken in accordance with methodologies of IEC 61000-4-7 or IEEE STD 519-1992 and have to be for at least 24 hours long at 10-minute measurement intervals.

3.3.3 Voltage Variations

The main Grid voltages shall be kept within the following limits in steady state and contingency operating conditions.

Table 3.3.3: Voltage Variations

	Normal Conditions		Emergency Conditions	
Nominal Voltage (kV)	**Maximum (KV)**	**Minimum (KV)**	**Maximum (KV)**	**Minimum (KV)**
400	420 (maximum)	380	420	357
330	346	313.5	363	297
220	232	209	242	198
132	138.6	125.4	145	118.8
110	115.5	104.5	121	99.0
88	92.4	83.6	96.8	79.2
66	69.3	59.4	72.5	56.1
33	34.7	31.4	36.3	29.7
11	11.6	10.5	12.1	9.9

[1*] Emergency conditions are those conditions not exceeding 30 minutes

3.3.4 Voltage Unbalance

The phase voltages of a 3-phase supply should be of equal magnitude and 120^{o} apart in phase angle. Deviations will result in decreased efficiency, negative torque, vibrations and overheating. Severe unbalance could lead to malfunctioning of some equipment. Voltage unbalance is defined as:

$$\text{Voltage Unbalance} = \frac{\text{Deviation between highest and lowest phases}}{\text{Average voltage of three phases}}$$

Limits for voltage unbalance are:

220kV and above: 2%
Below 220 kV: 3%

Balancing loads on individual phases will help greatly in avoiding unbalanced voltages.

3.3.5 Voltage Fluctuation and Flicker Severity

If the voltage fluctuates, the luminous intensity of the lamps and TV's will fluctuate correspondingly. If the fluctuation is of a magnitude and frequency perceptible to the eye, it becomes flicker. Flicker could range from annoying to complete interference of normal activity. Flicker is not usually produced by the power System but by customer loads such as arc furnaces, compressors, starting of large motors, etc. Since voltage fluctuation of the System affects other users on the same System, ZETCO shall direct the management of flicker on its lines and station buses. At the same time, flicker-generating loads connected to the System have to be controlled. ZETCO reserves the right to disconnect any excessive flicker generating load until the Grid User rectifies the problem.

3.3.5.1 Indicator of Quality for System Flicker

Flicker is the impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time. It is generated by customers and is indicated by the short-term flicker severity index index Pst, as defined in IEC Standard 61000-3-7 and measured with a flicker meter that meets the specification of IEC Standard 868 or IEC Std 61000-4-15. For the purpose of regulation, P_{st}, the short-term flicker severity index, is selected as the indicator of quality. Pst is considered to be the measure of visual severity of flicker derived from a time series output of a flicker meter over a ten-minute interval.

3.3.5.2 Limits

P_{st} = 1, which is equivalent to the threshold of perception, is the allowable level of flicker on the Transmission System. Tolerance for customer-generated flicker varies with the relative strength (short circuit ratio) of the load and voltage level. Limits are given in the following table.

Table 3.3.5: Limits of flicker produced by Users

Short Circuit Ratio S_L/S_{CC}	Voltage	Pst
$S_L/S_{CC} \leq 0.04$	HV	0.37
	EHV	0.58
$S_L/S_{CC} > 0.04$	HV	0.8
	EHV	1.0

3.3.5.3 Monitoring Control and Measurement

Substations, which supply heavy industrial loads such as furnaces, steel mills, etc., are targets for flicker monitoring. Other substations and Connection Point will be selected for monitoring on a random basis. At least one site is monitored each month. The list of monitoring points is submitted to Grid Users for approval at least 2 months before the monitoring. The flicker measurement will be conducted at 10-minute intervals according to procedures outlined in IEC Std 61000-4-15. Each site is measured for 1 week

3.4 Reliability Standards

System reliability of the Grid includes three aspects:

- System adequacy
- System security
- Service reliability

The compliance to System adequacy and security reliability standards shall be as specified in Section 4 of this Grid Code.

3.4.1 Service Reliability

The points where electric power is supplied from the Transmission System to the users (generation companies, distribution companies, another Transmission System, EHT customers) are called delivery points or Grid supply points. Outages at these points directly affect the users of the Grid. The reliability level at the delivery points is therefore an

indication of the quality of service provided by ZETCO to its users. Service reliability of the GRID is indicated by:

System Average Interruption Frequency Index **(SAIFI)**
System Average Interruption Duration Index **(SAIDI)**

Which are calculated as follows:

For each forced outage involving one or more delivery points and lasting more than 1 minute, the following parameters are recorded:

- Duration of outage in minutes: $\mathbf{T_i}$ **(min)**
- Sum of interrupted loads at all affected delivery points**:** $\sum \mathbf{P_i}$ **(kVA)**

$$SAIFI = \sum Pi / P_{total}$$
$$SAIDI = \sum(Pi \times Ti)/P_{total} \div 60$$

Where P_{total} = total sum of installed load at all delivery points

Note: Scheduled outages, which are communicated to the consumers beforehand and load shedding due to capacity shortage, are not counted in the computation of these indices

Table 3.4.1: Allowable Limits

SAIFI	SAIDI
24/yr	10 hours/year

3.5 Power Factor

3.5.1 General description

It is desirable that loads on the System have power factors at or close to unity as that represents the most efficient use of the System capability and the least loss of energy. It also eliminates many transient stability problems. Any load with a power factor lower than 90% is imposing an unfair burden on the Transmission System and other Users.

3.5.1.1 Limit

The minimum power factor allowed is 90%.

3.5.1.2 Control and Measurement

Power factor measurements are made continuously in conjunction with the voltage measurements. Loads with inherent low power factors should automatically include power factor correction equipment to correct the problem.

3.5.1.3 Penalty

A user with power factor worse than 90% may be refused connection to the transmission Grid until the problem is rectified. Alternatively, a penalty will be imposed based on load level and annualised cost of power factor correction capacitors.

3.5.2 Reactive Power Requirements

In general the Distribution Companies shall not depend on ZETCO for reactive power support. ZEDC and other Grid Users shall provide reactive compensation for their System. ZEDC and other Grid Users shall ensure that consumers having inductive load install capacitors so that at the interface with ZETCO the power factor is not less than 90%.

SECTION 4
PLANNING CODE

4.1 Introduction

Provisions of this Section are intended to enable ZETCO to produce a Network Development Plan and a Power Development Plan for demand and supply balance. This will be done in consultation with all Grid users in order to ensure an efficient, coordinated, secure and economical Grid network and power developments that will satisfy future demand requirements. The Section identifies the planning requirements for the Transmission and Sub-transmission Systems and the Generation System including Imports options. These will include the planning criteria, the planning processes and the tools to be used.

The addition of a new facility or the modification of an existing facility on the Transmission System may have a significant impact on the operation of the system. The impact needs to be analysed prior to the addition or modification of facilities.

ZERC shall monitor compliance to all matters covered by this section of the Grid Code and shall design and effect appropriate penalties for enforcing compliance.

4.2 TRANSMISSION SYSTEM PLANNING CRITERIA

The Zimbabwe Transmission System comprises of the 220 kV, 330 kV and the 420 kV (maximum) network and interconnectors to other SAPP utilities.

It is essential that this Transmission System is designed to ensure adequate, secure and acceptable reliability levels

4.2.1 Voltage Definitions

The following definitions apply for the voltages (normally) used on the ZETCO Transmission System

Table 4.1.1 Voltages (normally) Used on the ZETCO Transmission System

Highest voltage for equipment (kV)	Nominal System voltage (kV)
245 363 420 (maximum)[3*]	220 330 [1*)] 400 [2*)]

1*) Not a standard IEC voltage. Used within ZETCO for historic reasons.

2*) Not a standard IEC voltage. Used within SAPP.

3* Note that for safety purposes, the 400/420 (maximum) voltage shall be quoted as 420 (maximum) at all times

4.2.2 Normal Operation

The most common faults on the System are single-phase line-to-ground faults. Although use of high speed single-pole automatic reclosing (HSAR) limits the number of line outages due to single-phase faults, the System should be designed high enough to withstand such an event.

The more severe three-phase faults are rare. Designing the System to be able to withstand such a fault might therefore be excessively costly. The planning criteria therefore do not include any criterion regarding three-phase faults. However, the planner should check the System response to three-phase faults and evaluate reasonable measures to secure stability even under such conditions.

With all transmission lines in service, the System must be capable of a satisfactory supply of all bulk supply points both during peak and light load conditions. Switching off lines for voltage control during light load is accepted as long as this is not detrimental to the overall reliability.

4.2.2.1 Loading Limits

Thermal design ratings shall not be exceeded in steady state operation. These line ratings will be as per ZETCO designs as shown below and updated from time to time.

Table 4.1.2 Conductor Current Rating (MVA) for the Transmission System for Different Maximum Conductor Temperatures.

Conductor (mm^2)	Voltage (kV)	65 °C (MVA)	75 °C (MVA)	80 °C (MVA)
Twin Bison (2x350)	330	746	897	-
	420	945	-	-
Triple Bison (3x350)	330	-	1346	1444
	420 (maximum)	-	1632	1740

4.2.2.2 Voltage Limits

In steady state operation, main Grid voltages shall be kept within the following limits:

Nominal (kV)	Maximum (kV/p.u.)	Minimum (kV/p.u.)
330 kV:	346.5/1.05	313.5/0.95
400 kV:	420.0 (maximum)	380.0/0.90

4.2.3 Outage Conditions

The following outage criteria apply to the operation of the interconnected Transmission System. In general, the criterion requires that there shall be no loss of load for single contingency faults.

Note that radial lines at 220 kV or above, supplying loads in remote areas, are in this context considered part of the sub-transmission System, and the criteria given in Section 4.2 below should be applied to these parts of the System.

The criteria presented in the following is based on the assumption that all lines and all reactive power compensation plants are available for use prior to the fault, and that reserve is kept on the System.

4.2.3.1 Reserve Requirements

Supply to all bulk supply points shall be maintained following a sudden outage (without any prior fault) of any single Transmission System component (line, transformer, reactor, capacitor or SVC).

4.2.3.2 Stability Criteria

The System shall remain stable for a single line to ground fault with unsuccessful high-speed single pole re-close and definite three pole tripping.

The System shall withstand a sudden outage of any generating unit or block of units connected to the same transformer without loss of supply. (However, load shedding following an outage of the whole power station is accepted).

4.2.3.3 Loading Limits

For a single outage, the following load limits shall be applied once the new steady state has been reached, but prior to any operator intervention.

- Short-time (10 minutes) overloads of up to 15% on transmission lines shall be accepted if generation rescheduling is available (i.e. before operator action can be taken).

- Short-time (10 minutes) overloads of up to 15% on transformers shall be accepted (i.e. 400/330 kV and 330/220 kV transformers).

Limited overloads for short periods are not considered to bring the conductor temperature to critical values neither are they expected to increase sags too much. For most of the lines, the load in normal operation will be much lower than the thermal rating. It would therefore take time for the temperature even to reach the design rating of the line. Limited, short time overloads are for these reasons acceptable.

4.2.3.4 Steady State Voltage Limits

For a single outage, the following voltage limits shall be applied once the new steady state has been reached, but prior to any operator intervention.

- Main Grid voltages shall be kept within:

Nominal (kV)	Maximum (kV/p.u.)	Minimum (kV/p.u.)
- 330 kV:	363.0/1.10	297.0/0.90
- 400 kV:	420.0 (maximum)	357.0/0.89

4.2.3.5 Transient Voltage Deviations

The transient response of the System following a disturbance as observed in dynamic simulations is considered warranting further investigations if bus voltages swing outside the range of 0.8 to 1.2 p.u. for more than 500 milliseconds. This should be checked for adverse effects on motors, contactors and other voltage sensitive loads.

Voltage excursions below 0.7 p.u. any time even after a fault has been cleared successfully is considered to be unacceptable.

4.2.4 Other Criteria

4.2.4.1 Losses

Costs of losses shall be evaluated as part of the economic analysis of the different Transmission System alternatives. The analysis shall include evaluations on optimum line design (voltage and conductor type and configuration).

4.2.4.2 Line Design and Substation Design

When planning new 330 kV lines, it should be considered extensively whether the lines should be designed for 420 kV (maximum) operation to facilitate later uprating of the lines. For a substation fed from a line that has been designed for 420 kV (maximum) operation, but operated at 330 kV, extensive consideration should be given on the design of the substation including transformers, to be easily be convertible to 420 kV (maximum) operation.

It is expected that generator transformers and 420/330 kV transformers shall be designed such that they carry maximum output or line.

The standard way leaves shall be as follows: -

11kV……..10m

22kV……..10m

33kV……..15m

66kV……..30m

88kV……..30m

132kV……30m

330kV……60m

420kV……60m

In addition, the following line clearances shall be observed: -

Normal operating voltage between line conductors (in kV)	Over roads	Minimum clearance between conductors and rail top (in metres)
Up to and including 33	5.8	10.5
66	6.0	10.9
88	6.1	11.1
10 and 132	6.7	11.5
220	7.0	12.4
330 and 400	7.3	13.4

4.2.4.3 System Protection Schemes

To be able to increase the utilization of the investments already made in the Transmission System, use of special intelligent System protection schemes like automatic shedding of generation to avoid cascading line faults shall be evaluated. Such schemes can prove to limit the number of new lines needed on the System, and thus considerable investments can be saved.

4.2.4.4 Steady State Stability Limits

When evaluating the System's transfer limits, care should be taken to design the System with adequate margin to voltage collapse phenomena. Note especially that a voltage collapse might occur at voltage levels above the minimum operating levels indicated above. Transfer limits must ensure that a single outage does not bring the System into a steady state instability situation. The System should be regarded as unacceptable from a planning point of view if it runs out of voltage control range following a single contingency.

4.2.4.5 Maintenance Restrictions

The proposed "N-1" criterion used for the Transmission System does not take into account outages due to maintenance. The reason is that it has been assumed that no major maintenance will be carried out during peak load, which is considered to determine the design of the System. Depending on circumstances, it might be necessary for the planner evaluate the System even for "N-2" conditions, and weigh costs and benefits of designing the System to meet such a criterion. Planning of reactive power compensation plants are obvious candidates for such evaluations as such

plants are often connected via large power transformers that might have to be taken out of service at times when the reactive power compensation is needed the most.

In general, when evaluating different development strategies, those alternatives that are foreseen to better meet requirements during maintenance, should be preferred if the alternatives are otherwise comparable.

4.3 SUB- TRANSMISSION SYSTEM PLANNING CRITERIA

The Zimbabwe Sub-transmission System comprises of 66 kV, 88 kV, 110 kV, and 132 kV System.

The following planning criteria apply to the 66 kV, 88 kV, 110 kV and 132 kV Systems and any lines at higher voltage that only serve a local area supply function (for instance radial 330 kV lines and receiving end substations). Note that the 330 kV substation transformers are considered part of the sub-transmission System. The reason for this is that an outage of a 330/132(88) kV transformer will have no significant impact on the operation of the Transmission System, whereas it might cause a black-out in the sub-transmission System fed from the substation.

As opposed to a fault on the interconnected Transmission System, which might lead to a widespread blackout, a fault on the sub-transmission System will affect only one bulk supply point or a few sub-transmission sub-stations. The required reliability level on the sub-transmission System is therefore normally lower than in the bulk power Transmission System.

4.3.1 Voltage Definitions

The voltage definitions used in this manual are based on recommendations given in IEC Standard 38. This standard gives recommendations on both the highest voltage and the nominal voltage for equipment with a highest voltage not exceeding 245 kV

For normal operating conditions, the following voltage limits shall apply:

- Sub-transmission voltages shall be kept within:

Normal (kV)	Maximum (kV/p.u.)	Minimum (kV/p.u.)
- 132 kV:	138.6/1.05	125.4/0.95
- 110 kV:	115.5/1.05	104.5/0.95
- 88 kV:	92.4/1.05	83.6/0.95
- 66 kV:	69.3/1.05	59.4/0.95

4.3.2 Line Loading Limits

Thermal design ratings shall not be exceeded in steady state operation. These line ratings will be as per ZETCO designs as shown below and updated from time to time.

Table 4.3.2a Conductor Current Rating (MVA) for the Sub-Transmission Systeme's Different Maximum Conductor Temperatures.

Conductor (mm^2)	Voltage (kV)	50 °C (MVA)	65 °C (MVA)	75 °C (MVA)	80 °C (MVA)
Racoon (75)	66	16.5	30	36	-
	88	21.9	40	47	-
Dog [1]* (100)	66	18.6	36	42	-
	88	24.8	48	56	-
	132*	37	71	84	-
Wolf (150)	66	21.7	45	54	-
	88	29	61	72	-
	132	43	91	108	-
Twin Wolf (2x150)	88	58	121	144	-
	132	87	182	216	-
Single Lynx (175)	66	22.7	50	59	-
	88	30.3	66	79	-
	132	45	99	118	-
Twin Lynx (2x175)	88	61	132	157	-
	132	91	198	236	-
Single Panther (200)	66	23.8	54	64	-
	88	31.7	72	86	-
	132	48	108	128	-

Twin Panther	(2x200)	132	95	215	257	-
Bear [2*]	(250)	132	50	122	146	128
Single Bison	(350)	88	-	100	120	193
		132	-	149	179	385
Twin Bison	(2x350)	132	-	299	359	963

[1*] Dog conductor might cause excessive corona losses at 132kV and should preferably be avoided

2* For future purposes, and for the purpose of standardisation, the Bear conductor should not be used, in preference to the Lynx Conductor, which has comparable transfer capabilities, but is from cost consideration cheaper.

Table 4.3.2b Cable Current Rating (MVA) for different conductor sizes.

Type of cable	Voltage	Rating in MVA
0.1 Inch 3Core Copper cable	88 kV	29
300mm2 Al 3Core cable	88 kV	48
185mm2 3Core Copper cable	88 kV	85

4.3.3 Reserve Requirements

In the case of a single outage, the following reserve levels shall be considered:

- Loss of a 330 kV sub-station transformer (including banked transformers):

a) For sub-stations with a peak demand of 200 MW or more: Momentary reserve shall be secured for an outage of a single (or banked) transformer (see table in 4.2.3)

b) For substations with a peak demand of 100 MW to 200 MW:
After utilizing all available switching opportunities (i.e. including switching in healthy units of banked transformers and making use of backup opportunities from adjacent substations) there should be sufficient capacity to maintain full peak load supply.

c) For substations with a peak demand of less than 100 MW:
After utilizing all available switching opportunities (i.e. including switching in healthy units of banked transformers and making use of backup opportunities

from adjacent substations) there should be sufficient capacity to meet 80% of peak demand.

- Loss of a Single Sub-Transmission Line:

a) For loss of a line to an area with a peak demand of more than 200 MW:
After utilizing all available switching opportunities (i.e. including backup opportunities from adjacent substations) there should be sufficient capacity to maintain full peak load supply.

b) For loss of a line to an area with a peak demand of 100 MW to 200 MW:
After utilizing all available switching opportunities (i.e. including back-up opportunities from adjacent substations) there should be sufficient capacity to meet 80% of peak demand.

c) For loss of a line to an area with a peak demand of less than 100 MW:
No back up required. (Note that most line outages are expected to be short.)

- Loss Of A 132kV Substation Transformer

a) For a substation with a peak demand of more than 100MW, momentary reserve shall be provided.
b) For a substation with a peak demand of between 50 and 100MW:
After utilising all available switching options making use of back-up opportunities from adjacent substations, there should be available capacity to maintain 100% peak supply.
c) For a substation with a peak demand of less than 50MW:
There should be sufficient capacity at adjacent substations to maintain 50% of Peak Demand.

4.3.4 132 kV Transformer Loading Limits

The following 132kV transformer loading limits shall be applied following transformer outages. The set limits are based on IEC standards 38 or ZETCO design, assuming an ambient temperature of 30 deg. C. Momentary loading based on IEC standards 38 or ZETCO design is for a period of 30minutes.

Table 4.3.4 132 kV, 110 kV, 88 kV and 66 kV Transformer Loading (MVA)

	LOADING LIMIT (MVA)	
TRANSFORMER NAMEPLATE RATING (MVA)	**MOMENTARILY**	**CONTIUNUOUSLY**
90MVA (ONAF)	115	90
50/75MVA (ONAN/ONAF)	95	75
30/50MVA (ONAN/ONAF)	55	50
35/45MVA (ONAN/ONAF)	50	45
20/30MVA (ONAN/ONAF)	35	30
20MVA (ONAN)	23	20
10MVA (ONAN)	12	10
7.5MVA (ONAN)	8.5	7.5
5MVA (ONAN)	6	5
4MVA (ONAN)	4.5	4

4.3.5 330 kV Transformer Loading Limits

For a single outage, the following load limits shall be applied:

- No overloads on sub-transmission lines shall be accepted.
- The following 330 kV substation transformer load limits shall be applied both following line and transformer outages. (The limits are based on IEC standard 38 assuming an ambient temperature of 30 ^{o}C. Transformer load factors are accounted for.) Momentary loading based on the IEC standard 38 is for a period of 30 minutes.

Table 4.3.5 330 kV Transformer Loading Limits

Transformer Name-plate Rating	Load Limit (MVA)	
	Momentarily	Continuously
60 MVA (ONAF)	75	65
90 MVA (ONAF)	115	100
62.5/125 MVA (ONAN/ONAF)	140	125
125/175 MVA *) (ONAN/ONAF)	195	175

*) Note that the transformer impedance is matched to the ONAN rating. The economic operating range will therefore be close to the ONAN rating.

4.3.6 Voltage Limits

For a single outage, the following voltage limits shall apply:

- Sub-transmission voltages shall be kept within;

Nominal (kV)	Maximum (kV/p.u.)	Minimum (kV/p.u.)
- 132 kV:	145.2/1.10	118.8/0.90
- 110 kV:	121.0/1.10	99.0/0.90
- 88 kV:	96.8/1.10	79.2/0.90
- 66 kV:	72.6/1.10	56.1/0.90

4.3.7 Other Criteria

4.3.7.1 Losses

Costs of losses shall be evaluated as part of the economic analysis of the different System alternatives. The analysis shall include evaluations on optimum line design (voltage and conductor type and configuration).

4.3.7.2 Line and Substation Design

In general, all new sub-transmission projects should be designed for 132 kV operation although initially being planned for operation at 88 kV. All new 132 kV lines should be designed for a maximum conductor temperature of 75 ^{o}C.

4.4 NETWORK DEVELOPMENT APPROACH AND METHODOLOGY

This Section presents the approach and methodology to be adopted in the transmission planning process in ZETCO. The aim has been to lay a framework for the planning aspects involved in transmission and Sub-transmission System planning covering the required inputs, the expected constraints, the expected results and the basic steps to be taken.

The planning and design of the Transmission System is aimed at producing a network that is capable of transmitting electrical energy from the generating plants to the load centres in an economic, safe and reliable manner. The planning process itself tends to be complex since there is no single best solution to a problem. Certain selection processes have to be used to eliminate some alternatives and come up with a plan that satisfies the constraints to the maximum extent. In general, the planning process has been subject to developments and refinements over the years with improved software programs and powerful computers making it realistic to perform comprehensive calculations in shorter time frames.

Similar developments in the planning process are expected in future. Power System planning approach and methods will therefore be subject to amendments as experience is gained on the various study methods and limitations and drawbacks are realised.

4.4.1 Objectives

The Transmission System serves to transfer energy from the generating centres to the consumer and should do so in a reliable, safe and economic

manner. Transmission planning should thus result in least-cost transmission development plans that are capable of supplying the forecasted load while providing operational flexibility. The capability of transactions with neighbouring Systems as well as wheeling must also be considered. The System should operate within acceptable voltage limits and without dangerous or damaging overloads to equipment both under normal conditions and in emergencies.

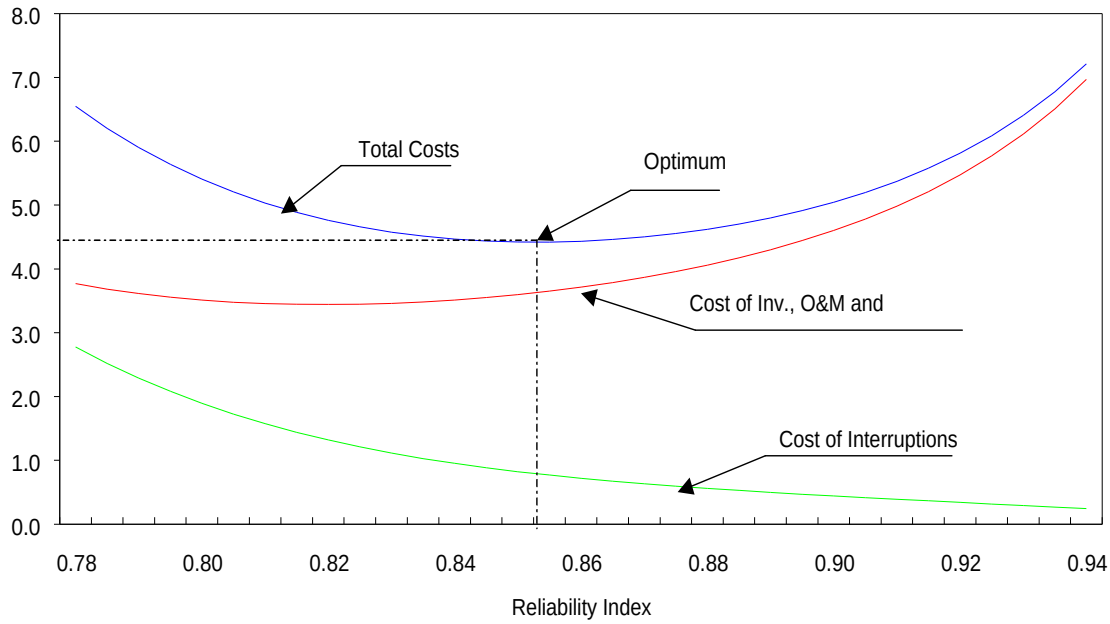
Good planning is based on a reasonable number of technically acceptable alternatives. The costs and benefits of each alternative, including environmental impacts, need to be compared in order to select the best alternative. Decision analysis techniques should be used to permit evaluation of non-cost factors.

4.4.2 Approach

The nature of Transmission System planning leads to a multi-objective evaluation of a number of alternative expansion scenarios that in most cases become an impracticable task. The normal approach in network planning is thus to carry out a technical analysis on the most promising development plans based on attaining certain reliability levels.

As the demand for a high quality electricity supply has increased, it has become important to express the reliability level using quantitative measures to facilitate the evaluation of different System development alternatives. This makes it possible to establish the balance between incremental worth of service quality improvement and incremental cost of providing that improvement. This becomes an optimisation problem where the total cost is the objective function and the required level of reliability becomes the point of minimum total costs as illustrated in Figure 4.4.2. A lot of work has now been devoted to the development of procedures and computer programs for reliability-based analysis.

Figure 4.4.2
System Costs as a Function of System Reliability



At present, Transmission System reliability levels are analysed using planning criteria that define allowable system responses. The criteria should be stringent enough to ensure a high quality of supply yet it must also be realistically cost effective in today's competitive environment. The criteria may be based on either deterministic or probabilistic approaches. The deterministic approach involves the specifying of allowable System response to specified contingencies or disturbances. Probabilistic approach involves limiting the risk of System failure or even limiting customer impact such as risk of loss of load, on the basis of outage statistics of System components.

Recent years have seen several developments in probabilistic reliability assessment procedures, which have been used to substantiate the need for System expansions. These have now been applied widely by some utilities. Reliable and detailed data for making failure models for most System components have been established having been assisted by reliability-based maintenance approaches being used in operating the network. However, the deterministic approach is viewed as adequate for the Zimbabwe System.

The deterministic approach is therefore still being used. The criteria developed apply to both static and dynamic conditions, requiring that the

System response to certain disturbances fall within prescribed limits. These limits often specify permissible voltage ranges, component loadings, frequency deviations and rotor angles. The limitation of the deterministic approach is that it does not provide a means of quantifying the worth of improved supply, which is required to justify System reinforcements. The deterministic approach is considered to be the best for the ZETCO System.

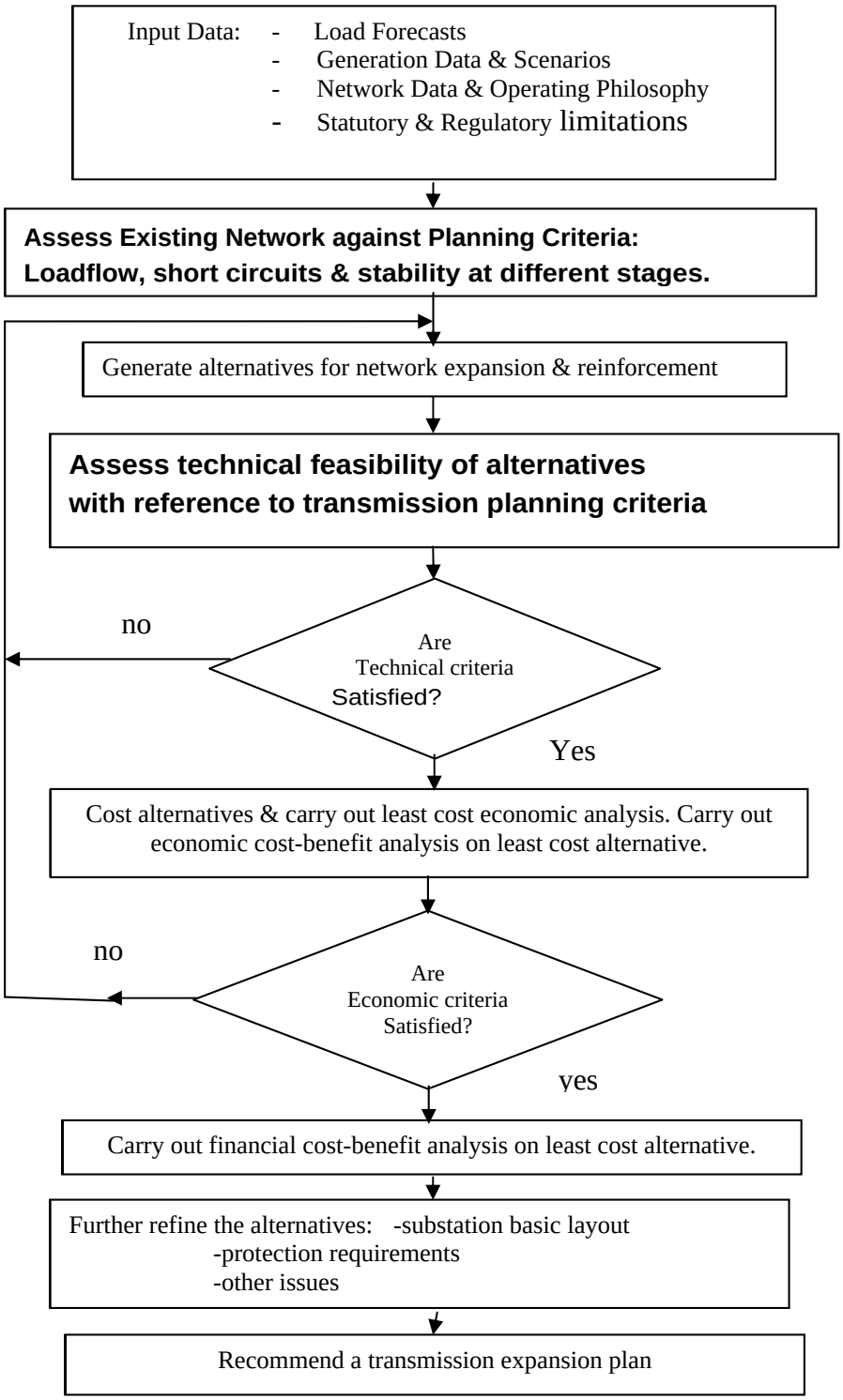
4.4.3 Methodology

4.4.3.1 Basis

As already stated, the transmission planning process is a complex one and hence there is a need to lay down some guiding steps as a means of providing uniformity to the transmission studies that are carried out in ZETCO. The System Transmission System developments plans shall be based on load forecast Generation System development plan and agreements for transactions with other utilities. Any external factors that might affect Transmission System planning should be addressed in the planning process. In general, the fundamental attributes of each plan can be assessed for technical, economic and environmental soundness. Some attributes cannot be expressed in monetary terms but that does not mean that they are insignificant. Environmental issues for example are basically of a qualitative nature but are becoming very important in infrastructure planning. Often such attributes are expressed as statutory regulatory limitations to the planning process.

Figure 4.4.3 illustrates the stages that are involved in the transmission planning process. An essential feature of this process is the screening of alternatives from an economic and technical point of view to avoid carrying out detailed studies on alternatives that are not competitive. The number of alternatives to be investigated is therefore reduced from one stage to the other. The remaining alternatives are then subjected to more detailed and time consuming studies.

Figure 4.4.3 Stages in the Transmission Planning Process.



4.4.3.2 Grid Planning Studies - Technical Analysis

ZETCO shall carry out Grid planning studies to ensure Reliability, Safety, Security and Stability of the Grid for the following:

- Preparation of the Transmission Development Plan (TDP) to be integrated with the Power Development Plan (PDP) in pursuant to the provisions of the Act.
- Evaluation of the Grid reinforcement projects and
- Evaluation of any proposed user development, which is submitted to the ZETCO in accordance with the application for connection.

The Grid planning studies shall be conducted periodically to assess the behaviour of the Grid during normal and outage conditions and also during electromechanical or electromagnetic transients induced by disturbances. The first screening process is through the technical analysis of the identified transmission expansion alternatives. The required inputs for this process are:

-load forecasts
- existing network
- committed expansion plans
- generation scenarios
- transactions with other utilities

The need for transmission expansion plans is determined by identifying any transmission constraints, limitations and bottlenecks in future based on the input data. Basic alternative development plans that would solve these problems are listed and engineering judgement is applied to screen these alternatives and remain with the most promising ones.

The most promising alternatives are assessed for their technical soundness against the planning criteria discussed above. The techniques applied ensure that all components are operating within prescribed limits and that voltages are within permissible ranges. Load flow analysis techniques are used at this stage of the process. For networks with obvious transient stability problems, initial investigations of System dynamic response will also be carried out at this stage. Fault analysis is normally carried out at a later stage of the planning process. In some cases System reliability analysis might be required as a basis for evaluating alternatives.

Transmission planning studies must be performed as necessary to determine the impact on the interconnected Transmission System when connecting new and/or modified generation, transmission, or end-use facilities to ensure the security and adequacy of the Transmission System. The results of these analyses will be used to determine if modifications must be made to maintain the reliability of the Transmission System. A detailed interconnection study is made up of the following components:

Load Flow Analysis
Fault Analysis
Stability Analysis

4.4.3.2.1 Load Flow Analysis

A model of the power System is used to simulate certain specified operating conditions. Load flow studies shall be performed to evaluate the behaviour of the existing and planned Grid facilities under forecasted maximum and minimum load conditions and to study the impact on the Grid of the connection of new generation plants, loads or transmission lines. The results predict power flow magnitudes and voltage levels under the loss of any individual System element. The load flow analysis enables the prediction of equipment overloads and the determination of excessive steady state voltage drops, which may be encountered.

4.4.3.2.2 Fault Analysis

Fault analysis will be performed to determine the effect of equipment additions or modification on the System fault currents. The studies shall also identify the most severe conditions that the Grid equipment may be exposed to. The fault studies data will be used to evaluate the impact of the new or modified installation on the interrupting capability or rating of the previously installed equipment such as circuit breakers and switches.

ZETCO shall maintain an up to date fault level database, which should be made available on request by Grid Users. ZETCO shall inform the Grid User, if fault levels at a Connection Point are likely to impact adversely on the User's Equipment connected to the Grid.

4.4.3.2.3 Stability Analysis

A stability analysis will be performed to determine the Transmission System's response to a sudden change in the state of the System due to faults on the System and unit outages. The stability analysis will determine:

i. Unit / station stability during faults
ii. Voltage levels and deviations
iii. Frequency levels and frequency deviations
iv. Synchronous generator rotor oscillations and real and reactive power outputs

4.4.3.3 Economic Analysis

Electricity plays a major role in the economic development of the country as a whole. Therefore the transmission development plans that result in a reliable network are core elements in the strategy for raising the economic and social welfare of citizens. There is aviability. This involves demonstrating that the proposed project is likely to contribute significantly to the development of the entire economy to justify the use of the resources envisaged for the project.

Cost-benefit analysis provides a tool of assessing the worth of a project to society. However it is not an easy task to identify and cost the benefits of some projects. This makes cost-benefit analysis a time consuming task and hence it becomes costly to carry out on all alternatives. Where the alternative projects are aimed at satisfying the same objective, a cost-effective analysis can be used to compare the alternatives. In transmission planning, least-cost analysis should be used to eliminate some alternative expansion plans. Cost-benefit analysis is therefore carried out on a few projects that are among the least cost solutions to the problem. These fewer alternatives would satisfy the set economic criteria in ZETCO. However in cases where the criteria are not met then alternatives are modified and thus the process becomes iterative.

4.4.3.4 Environmental Analysis

The environmental analysis focuses on the project's impact on the environment, both human and bio-physical, during construction, operation and de-commissioning.
The environmental impact study should provide baseline information to be used in monitoring environmental impacts and assessing the effectiveness

of mitigatory measures. Both negative and positive environmental impacts should be identified and quantified to the extent possible.

4.4.3.5 Financial Analysis

Financial analysis of a project involves determining the cost and revenue of the project. The costs give an indication of the funds needed to complete the project, while the revenue and sources of funds determine whether a project can sustain its financial obligations and have adequate working capital as well as generate sufficient cash flow to meet the project operational expenses. Above all the analysis should indicate whether the project is feasible by comparing the costs and benefits.

The project costs and benefits used in financial analysis should be provided and updated as and when necessary by ZETCO. The technique provides a measure of the profitability of the project. It is recommended that financial analysis should only be carried out on the screened alternatives that have been proved to be economically viable.

4.4.3.6 Final Selection

The final plans that have undergone the screening process listed above are further investigated and refined to provide the degree of detail required for the specification of the equipment. This may include fault analysis, analysis of operational contingencies and protection requirements. The investment necessary to satisfy these requirements is generally far outweighed by the investments required to satisfy the steady state and dynamic criteria covered in the early planning stages.

The process of transmission planning that has thus been described involves a trade-off between the level of detail and the number of alternatives studied. The technical analysis of transmission planning projects is carried out on a larger number of alternatives compared to the economical and financial analysis. The final transmission projects that would have gone through the above stages will then be incorporated in the System Development Plan (SDP).

4.3.4 Transmission Planning Tools

ZETCO shall employ planning software, which includes but not limited to Power System Simulator for Engineers (PSS/E) for the Transmission Planning.

4.5 POWER DEVELOPMENT

According to the provisions of the Electricity Act 13:19 ZETCO has the mandate for planning the Generation System for long term capacity including generation scheduling, commitment and dispatch. To maintain the capacity balance, it is necessary to ensure that there is adequate and reliable plant to meet the present as well as future consumption and demand as prescribed by the load forecast. Having achieved that, the total plant must be operated efficiently to minimize costs.

Four basic questions have to be answered in the course of the planning process. These are:

- WHAT capacities to install to ensure demand and supply balance?
- WHAT capacities to install to ensure an appropriate level of reliability?
- HOW to pick the best combination among the different technologies at hand now and in future?
- WHERE to locate this new generation equipment?
- WHEN is the proper time to incorporate them into the System?

The objective of a Power Development Plan (Generation Plan) is to establish when, where and what type and size of plant to build, in order to ensure an economic and reliable supply of forecasted load within a given planning period.

4.5.1 Planning Approach

ZETCO shall use a Least Cost Planning approach. A practical framework for least - cost utility planning should explicitly consider the major issues in resource planning and facilitate risk management. In this framework, demand and supply side options are simultaneously evaluated for cost -effectiveness.

The Dynamic System Optimisation (DSO) model is used for integrated demand, supply and financial planning. The DSO model performs the following functions:

* Optimises supply side options for conventional, renewable and non-traditional resources over the entire planning horizon.

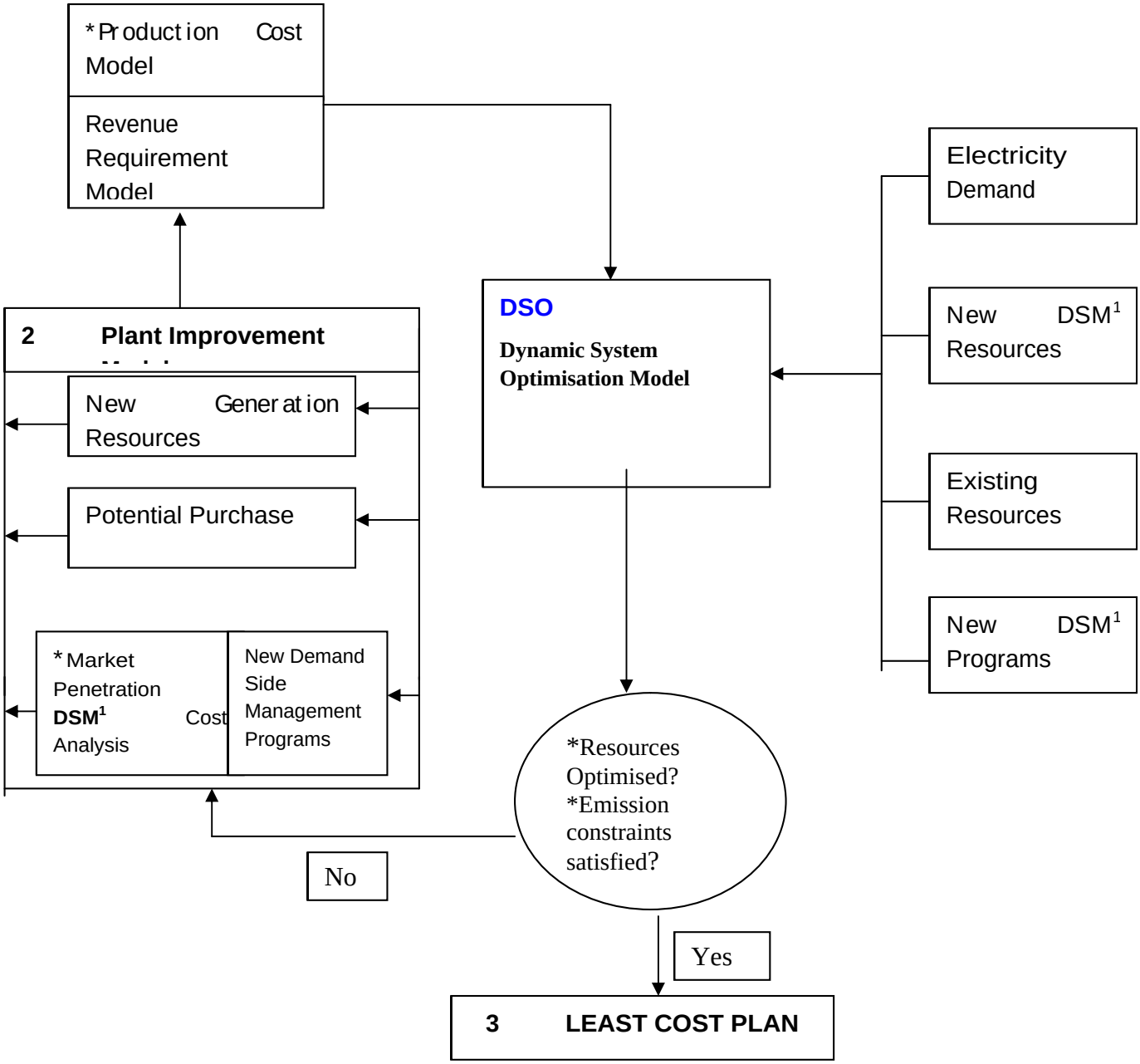
* Optimises demand side options including conservation and peak reducing programs.

* Selects new plants and Demand Side Management programmes to satisfy emission restrictions on SOx, NOx and particulates.

* Satisfies reliability requirements to meet the monthly reliability criteria.

Figure 4.5.1 Resource Integration: Dynamic System Optimisation Model

[1] Demand Side Management



Least Cost Planning approach entails emphasis on three key elements:

4.5.1.1 Load Forecasting

Electricity power supply and demand must be balanced at all times and the challenge for any electricity supply company is to provide a reliable electricity supply service at least cost. To meet this challenge it is necessary to plan for a level of investment that meets future energy consumption and maximum demand given by a load forecast. It is therefore of paramount importance to estimate what the load demand will be for the planning period.

Guessing wrong can be extremely costly. The major uncertainties in forecasting and planning should be explicitly recognised in the planning process. In order to minimise load-forecasting uncertainties, the load forecast for generation planning will mainly comprise of the low case, base case and high case as provided and updated by ZETCO on an annual basis or when the need arises robustness and flexibility are important planning goals.

Electrical demand and energy forecasting is mainly classified into three ranges: short, medium and long-term forecasts. The short term forecast is useful in determining unit commitment and economic dispatch; medium term forecasting is required for fuel procurement, maintenance scheduling and diversity interchanges; whereas the long- term forecast (annual peak and energy consumption forecast) is necessary for System expansion planning and financial analysis. Energy and demand are forecast on an annual basis for the 20-year planning period so as to provide a sufficient time horizon in providing future development options. ZETCO shall employ load-forecasting software, which includes but not limited to MAED.

4.5.1.2 Satisfying the Load Forecast / Developing Scenarios

After the Load Forecast is produced it is matched against the capacity and energy resources of the existing plants to see whether they can satisfy the requirements over the planning period. If the existing plants cannot meet the load forecast it then becomes necessary to find the best possible ways of meeting the demand reliably and at least cost, which is what Power Development Planning is all about. Several technically equivalent scenarios have to be evaluated to determine the least cost, taking into consideration three major criteria:

4.5.1.2.1 Criterion 1 (Reliability Criterion)

The minimum reserve level to be carried on the System should be at least 10.6% of Adjusted Demand for Thermal-based power and 7.6% for Hydropower and a weighted average for a combination of both. Adjusted Demand is equal to the Peak System Demand plus the amount of Firm Tariff Power exported minus the amount of Firm Tariff Power imported in the same interval.

4.5.1.2.2 Criterion 2 (Security Criterion)

The minimum level of internal generation shall have as a long-term objective, capacity equal to or greater than 100% of demand. Internal generation shall be committed when existing reserve levels drop below Criterion 1.

4.5.1.2.3 Criterion 3 (Economic and Financial Criterion)

For economic considerations Firm Imports may exceed the reserve margin limit as long as Criterion 2 is met and sources of energy are significantly diversified in both technology and geography and are cost effective relative to local options.

It is thus necessary to consider explicitly what level of adequacy is required for System planning. Overbuilding capacity will increase the average cost of generation because the costs of that extra capacity have to be borne by the customers. On the other hand, under building capacity will result in some portion of the demand not being served. If the economic cost of this unserved energy is added to the generation cost, this summed cost of generation also increases the degree of under building and the costs become severe.

Based on this Planning Criteria, equivalent competing scenarios are derived. The plant options in these scenarios should be what is practically available to the Planner.

4.5.2 Demand Side Management (DSM)

Customer demand can be influenced by utility actions. Demand -side options are available, viable and potentially useful alternatives to traditional generation -based strategies. Demand side management is the planning and implementation of those utility activities designed to

influence customer use of electricity in ways that will produce desired changes in the utility's load shape. The rationale for DSM as a part of overall utility planning is:

- The demand for electricity is not entirely beyond a utility's control. Rather than being exogenous, the timing and shape of load instead can be influenced by direct utility action in ways that contribute to meeting utility objectives.
- The fact that demand can be influenced makes it possible to consider an expanded range of options to meet the objective of balancing supply and demand.
- Demand side options can be used to complement or substitute for supply-side options.
- Compared with supply side alternatives, demand side options share characteristics that make them preferable to supply projects in the current planning environment.

The benefits are the savings in avoiding energy supply costs. These avoided costs are the marginal costs of the supply resource replaced by DSM. They include the reduction of transmission, distribution, generation and capacity costs for periods when the load has been reduced.

4.5.3 Options Available

All available options such as, but not limited to shall be considered as considered in the optimised generation expansion plan.

- Thermal options
- Hydro options
- Imports
- Non conventional and renewable energy sources

4.5.4 Operating Environment

With the advent of Independent Power Producers (IPP), the characteristics of the utility planning environment suggest four principles for improved decision making:

- Evaluate decisions as they affect customers and investors
- Analyse the effects of uncertain variables on the customer's cost of service and the investors return
- Consider the long - term consequences of investment decisions for the relevant range of uncertainties and for major

contingencies.

- Ensure that decisions are well documented with supportive studies and rationale for the purposes of public and regulatory retrospective review.

4.5.5 Generation Planning Tools

ZETCO shall employ planning software, which includes but not limited to WASP and UPLAN-E.

4.6 PLANNING DATA EXCHANGE

In order to ensure adequate planning and development of the Transmission Grid, ZETCO will require information pertinent to planning that may be resident in other companies such as ZEDC and any other customers connected to the Grid and ZPC and any other suppliers of power in the Grid. ZETCO should have full access to all the relevant data from these companies as and when the need arises. ZETCO shall provide standard data format for this purpose. A more detailed account of data requirements is given in Section 8 of this Grid Code. The information requirements shall basically include, but not limited to:

- Historical Energy and Demand
- Energy and Demand Forecast
- Dependable capacity
- ZERC and/or SAPP approved criteria
- ZEDC or any other User or Customer System Data

SECTION 5

OPERATIONS CODE

5.1 Introduction

ZETCO) is entrusted with the responsibility to transmit power and energy from the generating units and/or imports to the bulk and/or large customers in a safe, qualitative and secure manner.
ZETCO transmission grid is operated in parallel as an interconnected grid with other SADC utility transmission networks to form the Southern African Power Pool (SAPP). In pursuance of harmonised interconnected operation the SAPP has developed operating guidelines that are subscribed to by all the operating members. ZETCO takes cognisance of the SAPP requirements in developing and implementing of its own guidelines and procedures.

5.2 Purpose

Provisions of this Operations Section are intended to enable ZETCO to maintain a well-coordinated, safe and secure transmission grid that will deliver quality power. The provisions include guidelines on principles and procedures for system services provision; network switching (control) actions, demand/supply balancing, operational planning and event reporting. This will be done in consultation with all gird users (grid connected generators, grid connected customers and the distributors). These provisions may touch on, but not limited to, the following issues: -

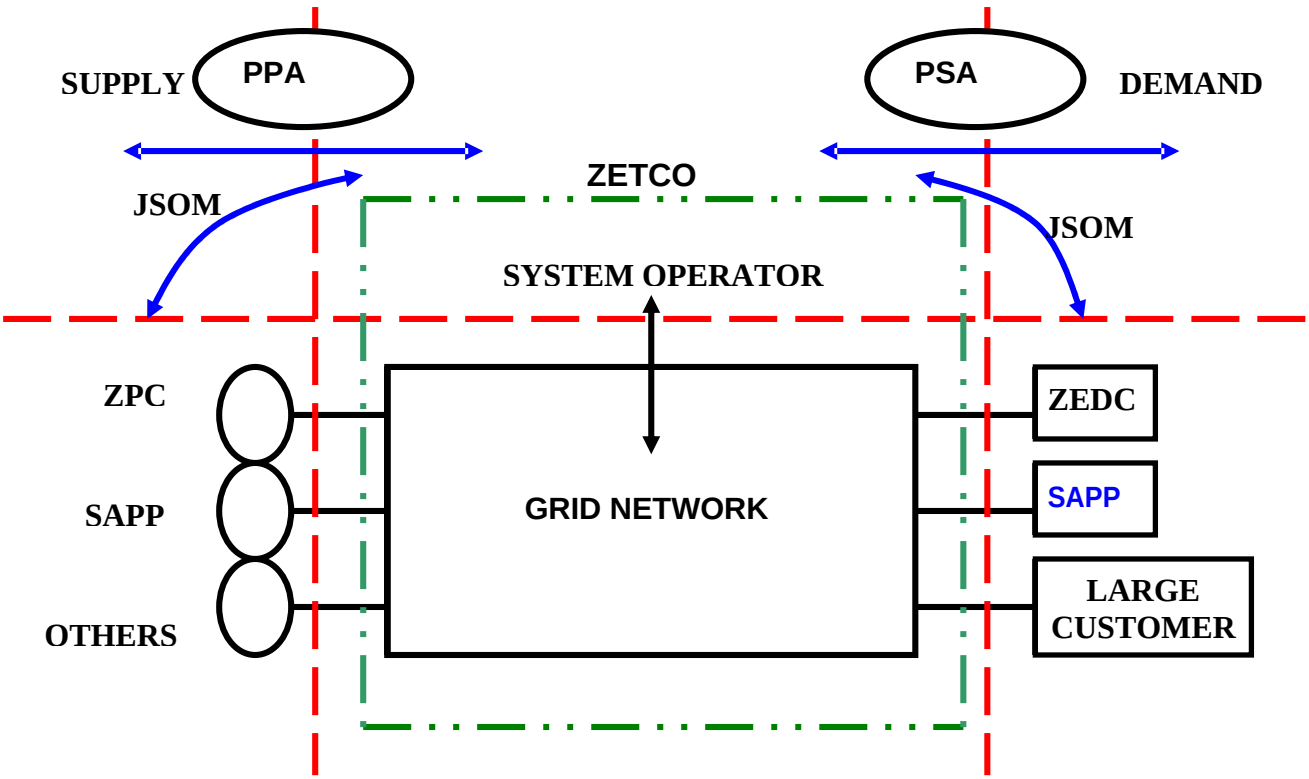
- ✓ Pre-dispatch and post-dispatch planning.
- ✓ Real-time system monitoring and control.
- ✓ Communication during normal and emergency conditions.
- ✓ Maintenance planning, co-ordination and execution.
- ✓ Generation scheduling and dispatch.
- ✓ Safety coordination.

5.3 Responsibility

Equipment ownership and demarcations shall be as per connection agreements between ZETCO and the grid Users. Control, Operation and maintenance of any equipment shall be as detailed in the Power Supply Agreement (PSA), Power Purchase Agreements (PPA) and Joint System Operational Memoranda.

All grid Users shall endeavor to operate their respective systems in synchronism at all the times. Security of power system and safety of personnel and/or equipment shall be accorded higher priority than economic considerations.

ZERC shall monitor compliance to all matters covered by this section of the Grid Code and shall design and effect appropriate penalties for enforcing compliance.



5.4 System Monitoring

ZETCO shall maintain a control centre that is manned 24 hours a day by an appropriate number of personnel for the purpose of system monitoring and control. The control centre must be equipped with a computer based supervisory, data acquisition and energy management system.

For effective operation of the transmission grid ZETCO shall continuously, in real time, monitor the following: -

(a) Actual generation unit active sent out power (MW) - it is important that the generator's declared availabilities are realistic and ZETCO advised of any departures as per provisions in PPA's.

Equally important all information on generator trips shall be urgently conveyed to ZETCO System Operator.

(b) Actual active power (MW) drawn by grid Users

(c) Tie line interchange

(d) Reactive power (MVAr) flows into or out of ZETCO grid. - This information is necessary for and will assist in voltage management.

(e) System frequency – this information gives an indication of the demand – supply balance.

(f) Voltage profiles in all stations and points of connection

(g) Equipment loading

5.5 System Services

System services are all services essential for the proper functioning of the transmission grid and which determine power quality. These services include, but not limited to, frequency control, voltage control and operating reserves. ZETCO shall ensure that the transmission grid is operated with adequate levels of these services. ZETCO shall advise Grid Users of the required contribution levels of the services where they are mandatory and shall itself, procure adequate levels where ZETCO has to self provide.

5.5.1 Frequency Control Service

ZETCO shall operate the grid in a manner that provides adequate frequency control within applicable limits at all times in order to maintain the security and integrity of the same. Both primary and secondary frequency control shall be as per recommendations from ZETCO.

5.5.1.1 Frequency Range

The frequency within the Southern African Power Pool (SAPP) is maintained and controlled jointly by all the interconnected utilities. The normal frequency shall be 50.0Hz with a statutory range of 47.5Hz – 52.5Hz. The operational range, which is narrower than the statutory band, shall be as recommended by the SAPP or ZETCO when operating in the interconnected or islanded mode respectively.

5.5.1.2 Frequency Control

a) All generators must operate under the control of a governor system at all times when synchronised to the grid.

b) All governors shall be capable of droop adjustments of between 3% and 6%. The actual governor settings to be implemented for

primary frequency control shall be as specified in the connection agreement.

c) No deliberate time delays shall be introduced in the governor control systems.
d) Frequency dead bands shall be as per recommendation from ZETCO in consultation with SAPP utilities.
e) Exemption for free governor mode for power stations not having free governor mode facility shall be sought from ZETCO.
f) ZETCO shall employ Automatic Generation Control (AGC) and manual actions for secondary frequency control. Generators required to be under AGC shall be specified in the connection agreement and those not operating under AGC shall continue to follow dispatch instructions from the System Operator.

5.5.1.3 Control Area Frequency and Interchange Control

ZETCO National Grid forms one of the Control Areas within SAPP. In line with the basic control requirement, ZETCO shall employ Automatic Generation Control (AGC) and manual actions for secondary frequency control. Generators required to be under AGC shall be specified in the connection agreement and those not operating under AGC shall continue to follow dispatch instructions from the System Operator.

The AGC shall meet the frequency and tie-line standards defined by SAPP.

5.5.2 Voltage Control Service

Voltages on the grid and at points of connection shall be maintained within the limits specified under section 5.5.2.1 of this code. In cases where the voltage limits are unique to the point of connection these shall be as specified in the connection agreements and / or joint system operational agreements. The duration and extent of voltage fluctuations shall also be limited under fault conditions. ZETCO shall employ both static and dynamic methods to maintain voltage stability, maintain voltages within limits and minimise system losses using methods that include but not limited to the following.

(a) Transformer tap changing.
(b) Reactor and capacitor switching.
(c) Static Var Compensators
(d) Generator reactive power capability.
(e) Demand management.
(f) Transmission lines charging capacitance

5.5.2.1 Voltage Range

The main grid voltages shall be kept within the following limits in steady state and contingency operating conditions so as to minimise system losses and to maintain quality of supplies.

	Normal Conditions		Emergency Conditions	
Nominal Voltage (kV)	**Maximum (KV)**	**Minimum (KV)**	**Maximum (KV)**	**Minimum (KV)**
400	420 (maximum)	380	420	357
330	346	313.5	363	297
220	232	209	242	198
132	138.6	125.4	145	118.8
110	115.5	104.5	121	99.0
88	92.4	83.6	96.8	79.2
66	69.3	59.4	72.5	56.1
33	34.7	31.4	36.3	29.7
11	11.6	10.5	12.1	9.9

Where standing instructions or special dispensations are in place the voltage might not follow guiding limits in the table above.

5.5.2.2 Voltage Control

a) Grid voltages will continuously be monitored and controlled accordingly. ZETCO shall adjust grid voltages using available control facilities.
b) Generator excitation systems shall be normally operated under a continuously acting Automatic Voltage Regulator (AVR) which shall be set to maintain a constant terminal voltage.
c) The ZETCO shall instruct the generators on what terminal voltage to maintain.
d) Generators may only disable the action of AVR if such action assists in improving on the reliability of the generator.
e) As an emergency measure ZETCO may implement demand shedding to prevent lower voltage limit excursions.

f) Line switching will be implemented only if it does not jeopardise system security.

5.5.3 Equipment loading

ZETCO shall continuously monitor the loading on all plant and equipment on the transmission grid. Thermal design ratings shall not be exceeded in steady state operation and for single outage. Short time overloads of up to 15% on transmission lines and transformers shall be accepted if generation rescheduling is available (i.e. before operator action can be taken). Otherwise ZETCOshall implement load management to relieve overloaded circuits.

Grid Users drawing power from ZETCO grid shall ensure that their loads do not affect ZETCO grid system in terms of causing any:

1. Unbalance in the phase angle and magnitude of voltage at the points of connection beyond the limits prescribed by ZETCO.
2. Harmonics in the system voltage at the interconnection point beyond the limits prescribed by ZETCO.

Should any one of the above two prevail ZETCO may direct the User(s) to take appropriate measures to remedy the situation.

5.6 Operational Planning

ZETCO shall be responsible for planning of the consolidated demand forecast, generation scheduling, demand control procedures outages and contingency plans.

5.6.1 Demand and Supply planning

All grid Users drawing power from ZETCO grid shall provide ZETCO, for all points of connection, with

i. Estimates of demand on a monthly basis for the year ahead
ii. Estimates of demand on daily basis for the month ahead.

Similarly each generator shall provide ZETCO with estimates of generation availability on monthly basis for the year ahead and on daily basis for month ahead.

ZETCO shall match the consolidated demands with consolidated generation availability and plan for demand control to ensure that there is a balance between the available power / energy and the demand (inclusive of system losses and required reserves).

5.6.2 Outage Planning

ZETCO and each User shall prepare an outage programme for the ensuing financial year for compilation of the overall outage plan for ZETCO grid. Each User shall obtain approval from ZETCO prior to availing the Outage. However, ZETC is authorised to defer any planned outage in case of any of the following events: -

a) Major grid disturbance
b) Security constrained dispatch
c) Unavailability of other equipment that has to be conditionally in service for the outage to go ahead

Any other event in the system that may have an adverse impact on system security by the proposed outage

5.6.3 Contingency Planning

The contingency plan and black start procedures shall be prepared by ZETCO in consultation with grid Users. The restoration process shall take into consideration generator capabilities and operational constraints of the transmission network. All users shall be aware of the requisite steps to be taken during the following: -

a) Partial system blackout
b) Total system blackout
c) Synchronisation of system islands

During system restoration following a disturbance normal standards of frequency and voltage shall not apply.

Users drawing load will identify non-essential components of their load for the purpose of keeping them off during system contingencies to aid in system restoration. The non-essential loads can be put on only when the system is restored as advised by the ZETCO. All Users shall pay special attention in carrying out the procedures so that secondary collapse due to undue haste or inappropriate loading is avoided. Despite the urgency of the situation, careful prompt and complete logging of all operations and

operational messages shall be ensured by all Users to facilitate subsequent investigation into the incident and the efficiency of the restoration process.

5.7 Records

ZETCO shall maintain a historical database of power and energy demand. This information is very useful as input to demand forecasting and for reconciliation and reporting.

5.7.1 Demand and Energy Data records

The following historical data shall be maintained to facilitate System Studies:

Energy produced by source of energy
Energy sent out by source of energy
Energy at the Connection Points and at 330 kV substations
System maximum demand
330 kV substations absolute maximum demand
330 kV substations demand at the time of the System Peak
330 kV substations demand at the time of the System Light Load
Sub-transmission substations absolute peaks
Sub-transmission substations loads at the time of 330 kV substations peak loads
Sub-transmission substations at the time of System peak load
Sub-transmission substations at the time of System light load

The data shall be captured on hourly basis and either an electronic copy or hard copy shall be kept and produced on request.

5.7.2 Safety records

Legibly written Switching Logs, in chronological order, shall be maintained by both and designated Senior Authorised persons for all operations and messages relating to safety co-ordination sent and received by them. All Switching Logs and safety documents issued for work on plant and / or equipment shall be retained for a period of not less than one year.

5.7.3 Fault Recording And Reporting

When a fault occurs on the power system it causes unplanned changes in the Active Power, Reactive Power, Voltage, Current and/or Frequency associated with the transmission grid.

Fault reports for all faults on the ZETCO grid shall be generated. Equally all Users whose equipment is faulted and impacts on the ZETCO grid must report the details of such a fault to ZETCO at the earliest opportunity. ZETCO shall record permanently all relevant information pertaining to the fault.

Fault reports shall contain, but not limited to, the following information:

a) Date and time of Fault
b) Location of Fault
c) Circuit Breaker(s) operations
d) Cause of Fault
e) Injuries to Persons and/or Damage to Plant
f) Load Interrupted and Duration of Interruption
g) Protection Operations
h) Any other relevant information

The fault reports for ZETCO grid related disturbances shall be made available to Users on request through the Regulator.

5.8 Safety Coordination

5.8.1 Responsibility

This section specifies safety requirements to be used by ZETCO and all Grid Users so as to maintain safety of plant and / or equipment and personnel. ZETCO shall be the custodian of safety procedures and documents used when working on plant and / or equipment on the transmission grid and at all points of connection with the Users. ZETCO does not, however, seek to impose these safety requirements for work outside the transmission grid network and beyond the points of connection. Only competent persons dully authorised by ZETCO shall be permitted to carry out any work and network switching on the transmission grid and at the point of connection. The safety requirements are as captured in the Zimbabwe Electricity Supply Authority Electrical Safety Rules and the supplementary Live Line Safety Rules.

5.8.2 Authorised Persons

A list of the Senior Authorised persons (names, designations and telephone numbers) for the ZETCO transmission grid and for Users at points of connection shall be circulated to all ZETCO and all grid Users. The list must be updated promptly whenever any of the information changes.

5.8.3 Work On Plant and Equipment

Work must commence only after it has been made safe to work on through the following steps.

i. Made dead – source of power removed.
ii. Isolated – physically disconnected form source of power.
iii. Earthed – connected to the earth.
iv. Safety documents issued

The designated Senior Authorised person shall ensure that adequate safety precautions are established and maintained through out the work. The equipment shall only be considered as suitable for return to service when all safety documents have been cancelled and isolation points normalized.

5.8.3 Electrical Accidents

In the event of an electrical accident on the ZETCO grid or at points of connection the following steps shall be taken:

a. Stop work and attend to the injured if any.
b. Notify ZETCO Controller, who will decide whether work should continue or not.
c. Report Incident to Zimbabwe republic Police.
d. Produce a preliminary report and notify management.
e. If necessary management constitutes a committee for further investigation
f. Produce a detailed accident report.
g. Circulate report internally and to key people in the Users systems.
h. Officially advise the ministry of the accident.

5.9 Communications

Telecommunications are the basic infrastructure that makes remote operations of a system possible. It is, therefore, imperative that telecommunications be highly reliable, and highly available.

ZETCO System Operator ZETCO and Users shall advise each other of the telephone numbers to be used for operational purposes. ZETCO shall ensure that all operational lines are monitored for future replay should any disputes arise or as a tool in incident investigation.

In the case of problems with direct TelOne calls, a priority call can be obtained by dialling the local operator, stating "URGENT ELECTRICITY CALL" and asking for the required number. The Operator will consider the call as an emergency and obtain the number with minimum delay. The Postmaster General (PMG)'s Circular No. 40 of 1983, which may be quoted in the event of misunderstanding, covers the above procedure.

Use of mobile communication should be used as a last resort.

5.10 Demand Control

Provisions of this section are to enable ZETCO to implement demand reduction or demand addition in a manner that ensures the continued balance between supply and demand. Demand reduction will help in maintaining system integrity in cases of demand – supply mismatch and equipment overload. Similarly a demand addition (reconnection) will assist in achieving controlled picking of demand.

ZETCO shall be responsible for issuing instructions for to Users for picking or dropping load under normal or emergency conditions.

5.8.2 Planned Demand Control

In the case of a supply – demand mismatch is foreseen ZETCO will alert Users drawing power from ZETCO grid in terms of the times and load quantum to be curtailed.

ZETCO and Users shall produce a load shedding programme that will be followed when there is planned load demand control.
Where there is not enough time to notify Users ZETCO shall curtail load in a manner that does not strictly follow the agreed load shedding programme.

5.10.2 Automatic (Emergency) Demand Control

Emergency operating conditions requiring automatic demand control occur when there is a sudden loss of generation substantially in excess of spare plant capacity. ZETCO in consultation with grid Users shall prepare the plan for automatic load shedding during the low frequency conditions.

During periods of low frequency conditions generating stations shall assist through the following:

a. Endeavour to assist the system frequency to rise to 50 Hz, by increasing generation whenever possible.
b. Not disconnecting manually from the transmission system unless there is definite evidence that a complete failure of generation would otherwise result.

The person in charge at each generating station, however, will retain the right to shut down plant if he/she considers that its continued operations would be unsafe, or would result in breakdown of the plant.

5.11 Power System Restoration After Blackout

ZETCO System Operators are required to direct and co-ordinate restoration efforts after blackouts. This can only be achieved safely and quickly by using a well-organised and systematic approach as specified in this Section.

It is incumbent on all grid Users authorised to carry out switching on the network to be thoroughly familiar with and observe the following restoration procedures:

a) ZETCO and the Grid Users are required to accurately assess the extent of the blackout and the status of plant and equipment, and from available information determine the best method for restoring supplies. Important operational requirements, critical loads, alternative supply options, etc should receive the required priority.
b) ZETCO and the Grid Users should safely and quickly restore supplies by carrying out switching, directing and co-ordinating staff involved in the exercise. They must not get involved with non-operational matters, especially to answer queries from other staff and the public.
c) ZETCO shall direct and co-ordinate system restoration with Users and interconnected utilities in accordance with standing instructions and laid down procedures.

d) Generating station Operators shall direct and co-ordinate the start-up of generating machines to be ready for synchronising in accordance with local standing instructions and procedures.
e) Restoration work should be conducted in accordance with all applicable operating rules and memoranda, in particular ZESA's Electrical Safety Rules must be complied with. Statutory, equipment, operational and other constraints must be observed.
f) The respective Operators must ensure that an accurate and complete log is maintained. This is required for post event analysis and may be of assistance during the emergency.

All switching operations on the ZETCO shall be in line with provisions of the ZESA Electricity Safety Rules. No part of the ZETCO grid shall be deliberately isolated from the integrated network except under the following conditions.

- ✓ Under an emergency, and conditions in which such isolation would prevent a total grid collapse and/or enable early restoration of power supply
- ✓ When serious damage to costly equipment is imminent and such isolation would prevent it
- ✓ On operation of ZETCO approved under frequency/islanding scheme

Complete synchronisation of integrated grid shall be restored, as soon as the conditions again permit it. ZETCO shall supervise the restoration process.

5.12 Schedule And Dispatch

ZETCO shall prepare the day ahead generation schedule keeping in view the following:

a) ZETCO grid constraints from time to time
b) Load requirements as estimated through consolidating User demands for specified intervals
c) The need to provide operating margins and reserves required to be maintained
d) The availability of generation from various sources together with any constraints in each case

The Generation Scheduling shall be in accordance with the Power Purchase Agreements (PPA's). Generators shall promptly inform ZETCO in

the event of any unforeseen difficulties in carrying out dispatch instructions. Dispatch instructions shall be issued by fax and confirmed by return fax. In the event that oral instructions are used these shall be complied with forthwith and written confirmation shall be issued promptly by Fax, e-mail, tele-printer or otherwise.

5.13 Network Switching

ZETCO needs to carry out network switching in order to implement maintenance outage programmes, connect new systems, facilitate system and / or protection tests, control voltage, load management and to respond to emergency and fault situations on the transmission network.

ZETCO shall inform Users, where practicable, of switching actions that may be likely to affect the operations of Users or security of supply to Users. In this regard ZETCO shall consult with Users in order to find out and take into consideration reasonable objections raised by the same.

Network switching may also occur automatically and without advance warning due to operation of protection equipment to clear or isolate faults or established deliberately to mitigate negative impact of faults on voltage and equipment loading.

5.14 System test

5.14.1 System Test Requirements

5.14.1.1 System Test, which involves the simulation of conditions or the controlled application of unusual or extreme conditions that may have an impact on the Grid or the User System, shall be carried out in a manner that shall not endanger any personnel or the general public.

5.14.1.2 The threat to the integrity of Equipment, the Security of the Grid, and the detriment to ZETCO and other Users shall be minimized when undertaking a System Test on the Grid or the User System.

5.14.2 System Test Request

5.14.2.1 If ZETCO (or a User) wishes to undertake a System Test on the Grid (or the User System), it shall submit a System Test Request that contains the following:

- The purpose and nature of the proposed System Test;

- The extent and condition of the Equipment involved; and
- A proposed System Test Procedure specifying the switching sequence and the timing of the switching sequence.

5.14.2.2 The Test Proponent shall provide sufficient time for the planning of the proposed System Test shall determine the time required for each type of System Test.

5.14.2.3 ZETCO may require additional information before approving the proposed System Test if the information contained in the System Test Request is insufficient or the proposed System Test Procedure cannot ensure the safety of personnel and the Security of the Grid.

5.14.2.4 ZETCO shall determine and notify other Users, other than the System Test Proponent, that may be affected by the proposed System Test.

5.14.2.5 ZETCO may also initiate a System Test if it has determined that the System Test is necessary to ensure the safety, Stability, Security, and Reliability of the Grid.

5.14.3 System Test Group

5.14.3.1 Within one (1) month after the acceptance of a System Test Request, ZETCO shall notify the System Test Proponent, (if it is not the System Test Proponent) and the affected Users of the proposed System Test. The notice shall contain the following:

j) The purpose and nature of the proposed System Test, the extent and condition of the Equipment involved, the identity of the System Test Proponent, and the affected Users;

k) An invitation to nominate representative(s) for the System Test Group to be established to coordinate the proposed System Test; and

l) If the System Test involves work or testing on HV and EHV Equipment, the Safety Coordinators and the safety procedures specified in the Electrical Safety Rules Hand Book shall be adhered to.

5.14.3.2 The System Test Proponent, and the affected Users shall nominate their representative(s) to the System Test Group within one (1) month after receipt of the notice to ZETCO. ZETCO may decide to proceed with the proposed System Test even if the affected Users fail to reply within that period.

5.14.3.3 ZETCO shall establish a System Test Group and appoint a System Test Coordinator, who shall act as chairman of the System Test

Group. The System Test Coordinator may come from ZETCO or the System Test Proponent.

5.14.3.4 The members of the System Test Group shall meet within one (1) month after the Test Group is established. The System Test Coordinator shall convene the System Test Group as often as necessary.

5.14.3.5 The agenda for the meeting of the System Test Group shall include the following:

(a) The details of the purpose and nature of the proposed System Test and other matters included in the System Test Request;
(b) Evaluation of the System Test Procedure as submitted by the System Test Proponent and making the necessary modifications to come up with the final System Test Procedure;
(c) The possibility of scheduling simultaneously the proposed System Test with any other test and with Equipment Maintenance which may arise pursuant to the Maintenance Program requirements of the Grid or Users; and
(d) The economic, operational, and risk implications of the proposed System Test on the Grid, the System of other Users, and the Scheduling and Dispatch of the Generating Plants.

5.14.3.6 The System Test Proponent, ZETCO (if it is not the System Test Proponent) and the affected Users (including those which are not represented in the System Test Group) shall provide the System Test Group, upon request, with such details as the System Test Group reasonably requires to carry out the proposed System Test.

5.14.4 System Test Program

5.14.4.1 Within two (2) months after the first meeting and at least one (1) month prior to the date of the proposed System Test, the System Test Group shall submit to ZETCO, the System Test Proponent and the affected Users a proposed System Test Program which shall contain the following:

(a) Plan for carrying out the System Test;
(b) System Test Procedure to be followed during the test including the manner in which the System Test is to be monitored;
(c) List of responsible persons, including Safety Coordinators when necessary, who will be involved in carrying out the System Test;
(d) An allocation of all testing costs among the affected parties; and

(e) Such other matters as the System Test Group may deem appropriate and necessary and are approved by the management of the affected parties.

5.14.4.2 If the proposed System Test Program is acceptable to ZETCO, the System Test Proponent and the affected Users, the final System Test Program shall be constituted and the System Test shall proceed accordingly. Otherwise, the System Test Group shall revise the System Test Program.

5.14.4.3 If the System Test Group is unable to develop a System Test Program or reach a decision in implementing the System Test Program, ZETCO shall determine whether it is necessary to proceed with the System Test to ensure the Security of the Grid.

5.14.4.4 The System Test Coordinator shall be notified in writing, as soon as possible, of any proposed revision or amendment to the System Test Program prior to the day of the proposed System Test. If the System Test Coordinator decides that the proposed revision or amendment is meritorious, he shall notify ZETCO, the System Test Proponent, and the affected Users to act accordingly for the inclusion thereof. The System Test Program shall then be carried out with the revisions or amendments if the System Test Coordinator received no objections.

5.14.4.5 If System conditions are abnormal during the scheduled day for the System Test, the System Test Coordinator may recommend a postponement of the System Test.

5.14.5 System Test Report

5.14.5.1 Within two (2) months or a shorter period as the System Test Group may agree after the conclusion of the System Test, the System Test Proponent shall prepare and submit a System Test Report to ZETCO, the affected Users, and the members of the System Test Group.

5.14.5.2 After the submission of System Test Report, the System Test Group shall be automatically dissolved.

5.15 Generating unit capability tests

5.15.1 Test Requirements

5.15.1.1 Tests shall be conducted, in accordance with the agreed procedure and standards, to confirm the compliance of Generating Units for the following:

(a) Capability of Generating Units to operate within their registered Generation parameters;

(b) Capability of the Generating Units to meet the applicable requirements of the Grid Code;

(c) Capability to deliver the Ancillary Service that the Generator had agreed to provide; and

(d) Availability of Generating Units in accordance with their capability declaration.

5.15.1.2 All tests shall be recorded and witnessed by the authorized representatives of ZETCO, Generator, and/or User.

5.15.1.3 The Generator shall demonstrate to ZETCO the reliability and accuracy of the test instruments and Equipment to be used in the test.

5.15.1.4 All tests shall be of sufficient duration and shall be conducted according to The Power Purchase Agreement with ZPC or any other Generator or Supplier except when there are reasonable grounds to justify the necessity for further tests.

5.15.1.5 If a Generating Unit fails the test, the Generator shall correct the deficiency within an agreed period to attain the relevant registered parameters for that Generating Unit.

5.15.1.6 Once the Generator achieves the registered parameters of its Generating Unit that previously failed the test, it shall immediately notify ZETCO. ZETCO shall then require the Generator to conduct a retest in order to demonstrate that the appropriate parameter has already been restored to its registered value.

5.15.1.7 If a dispute arises relating to the failure of a Generating Unit to pass a given test, ZETCO, the Generator and/or User shall seek to resolve the dispute among them.

5.15.1.8 If the dispute cannot be resolved, one of the parties may submit the issue to the respective Board, the Holding Company and the ZERC in that order.

5.15.2 Tests to be performed

5.15.2.1 The Reactive Power test shall demonstrate that the Generating Unit meets the registered Reactive Power Capability requirements. The Generating Unit shall pass the test if the measured values are within: 1.5 percent of the Capability as registered with ZETCO.

5.15.2.2 The Primary Response test shall demonstrate that the Generating Unit has the capability to provide Primary Response

5.15.2.3 The Generating Unit shall pass the test if the measured response in

MW /Hz is within: 1.5 percent of the required level of response within five (5) seconds.

5.15.2.4 The Fast Start capability test shall demonstrate that the Generating Unit has the capability to automatically Start-Up, synchronize with the Grid within 15 minutes and be loaded up to its offered capability. The Generating Unit shall pass the test if it meets the Fast Start capability requirements.

5.15.2.5 The Black Start test shall demonstrate that the Generating Plant with Black Start cap-ability can implement a Black Start procedure. To pass the test, the Generating Unit shall start on its own, synchronize with the Grid and carry load without the need for external power supply.

5.15.2.6 The Declared Data capability test shall demonstrate that the Generating Unit can be scheduled and dispatched in accordance with the Declared Data. To pass the test, the unit shall satisfy the ability to achieve the Declared Data.

5.15.2.7 The Dispatch accuracy test shall demonstrate that the Generating Unit meets the relevant Generation Scheduling and Dispatch Parameters. The Generating Unit shall pass the test if:

(a) In the case of synchronization, the process is achieved within: 1.5 minutes of the registered synchronization time;
(b) In the case of synchronizing generation (if registered as a Generation Scheduling and Dispatch Parameters), the synchronizing generation achieved is within an error level equivalent to 2.5% of Net Declared Capability;
(c) In the case of meeting ramp rates, the actual ramp rate is within: Plus or minus 10% of the registered ramp rate;
(d) In the case of meeting Load reduction rates, the actual Load reduction rate is within: plus or minus 10% of the registered Load reduction rate; and
(e) In the case of all other Generation Scheduling and Dispatch Parameters, values are within: plus or minus 1.5% of the declared values.

5.15.2.8 The Ancillary Service acceptability test shall determine the committed services in terms of parameter quantity or volume, timeliness, and other operational requirements. Generators providing Ancillary Services shall conduct the test or define the committed service. However, monitoring by ZETCO of Ancillary Service performance in response to System-derived inputs shall also be carried out.

5.16 Maintenance Requirements

5.16.1 Transformer Oil Containment

All transformers shall be placed on specially designed foundations. An oil sump shall be provided in the switchyard at a lower level than the transformer foundation.

The trench to the sump shall have a well-designed gradient with tile finish to enable oil flow from transformer cavity.

5.16.2 Equipment Maintenance

5.16.2.1 Maintenance Schedule for Switchgear

ZETCO shall design a maintenance schedule for annual inspections of the annual conditions and performance of transformers and switchgear.

Compressed air systems for Circuit Breakers shall undergo a statutory inspection and the dryness of the air should be ensured.

5.16.2.2 Maintenance of Transformer and Switchgear Dielectric Oil

Oil Samples shall be taken periodically and tested for moisture, dielectric strength and decomposition products. Filtration or Regeneration is recommended if oil tests are not satisfactory. The test shall be done according to the following standards: IEC 599; IEC 422(1998); IEC 354; IEC 156 and IEC 296.

5.16.2.3 Maintenance of Power Transformers

The transformer shall be inspected regularly. Regular inspection, annual checks and condition-based maintenance are essential for long, trouble-free service.

5.16.3 Infrared Thermograph

Infrared Thermograph shall be carried out on the substation equipment at least once a year to ascertain equipment availability and personnel safety. The purpose of the infrared scanning is to check on loose connections.

5.16.4 Noise level measurements

Noise level measurements shall be done using a noise level meter. Transformers, Coolers, Radiators, Auxiliaries and Air-conditioning plant noise level shall be below specified limit of 78dB. Corrective measures shall be taken if the limits exceed the above stated level.

5.16.4 Polychrobiphenyls (PCB) Management

All transformers and switchgear oil shall be tested for PCBs and if contaminated, the oil container or the equipment in which the oil is contaminated shall be clearly labelled "PCB equipment" for personnel protection. The contamination level above is 50ppm.

PCB Contaminated Waste disposal shall be by incineration.

5.16.5 Live Line / Dead Line Maintenance

Routine insulator inspection and replacement of damaged insulators shall be carried out annually on all feeders.

For feeders deemed critical by ZETCO, live line inspection and replacement of damaged insulators shall be carried out when and where necessary.

5.16.6 Line Way Leaves Maintenance

Bush clearing and Track maintenance shall be carried out annually for all Transmission and sub transmission lines.

5.16.7 Battery Maintenance

The total battery voltage shall be checked monthly. The total voltage shall be equal to cell voltage x n. Where n is the number of cells in a bank.

The voltage specific gravity and temperature of each battery cell shall be measured and recorded every month. If the measured value is outside the specified limits by SAZ standard, remedial action shall be effected.

Electrolyte levels of all cells shall be checked monthly. If below minimum level, it shall be topped up with distilled/ deionised water to the level marked "Maximum"

The float charge shall be set at cell rated voltage.

5.16.8 Circuit Breaker Tests (SF6 And Vacuum)

Circuit breakers shall undergo annual timing test. The closing and opening times shall be determined and compared to the manufactures prescribed close open times. If outside the prescribed limits, then appropriate remedial action shall be effected.

Circuit breakers shall undergo annual dynamic resistance tests to ascertain contact integrity.

SECTION 6

METERING CODE

6.1 Introduction

This Grid Code sets out a uniform policy in respect of electricity metering at boundaries between entities (Connection Points) so that the transfer of electrical energy is properly accounted for.

6.2 Objective

The objective of the Code is to define the minimum acceptable metering standards for the purpose of accountability, billing of electrical energy at the Connection Point as specified in the Connection Agreement.

The Code also specifies the requirement of calibration, testing and commissioning for metering equipment. The Code broadly indicates the technical features of various elements of the metering, security, meter reading and the procedure for the resolution of disputes.

6.3 Scope

The scope of this Code covers the practices that shall be employed and the practices that shall be provided for the measurement and recording of various parameters like energy pulses, Active/Reactive power etc.

6.4 Application of the Metering Code

This Section of the Grid Code applies to all stakeholders in respect of any metering point, which connects to the Transmission Grid. This Section of the Grid Code sets out provisions relating to:

a) Provision, and maintenance of metering equipment;
b) Collection of metering data;
c) Accuracy of all equipment used in the process of electricity metering;
d) Testing procedures to be adhered to;
e) Storage requirement for metering data;
f) Competencies and standards of performance; and
g) Relationship of entities involved in the electricity metering industry.

ZERC shall monitor compliance to all matters covered by this section of the Grid Code and shall design and effect appropriate penalties for enforcing compliance.

6.5 Metering Equipment

The metering equipment at the Connection Point shall consist of some or all of the following:

(a) Instrument transformers;
(b) Lightning protection;
(c) Revenue class meters;
(d) Integrating pulse recorder(s) and time source; and
(e) Test interfaces to include test blocks

6.6 Active Energy and Demand Metering

Active Energy and Demand Metering shall be required at every Connection Point. Active Energy and Power exported or imported by parties shall be metered and generating units/ Grid substations shall be monitored as required.

6.7 Tariff Metering

Tariff metering shall be designed and installed so as to measure imports from generators and exports to Grid Users. As far as possible the tariff metering shall be connected at the delivery point i.e., for energy exported from generators to the Grid at the HV side of the generator transformer (step up transformer) and for energy imported from the Grid for station consumption on the HV side of the station transformer.

Tariff metering for the imports/ exports on inter-connectors shall be installed at the receiving/ sending substation. The meters, however, must be configured to compensate for losses from/to the National Border.

Similarly, at the Connection Point with Grid Users, two meters shall be installed - One Main and the other Check.

6.7.1 The meter pulses shall be made available to ZETCO to allow separate recording of the input and output Active Energy and Power at each Connection Point.

6.7.2 The Reactive Energy and Demand metering shall be provided to independently meter input and output from the Grid. It shall

measure all quadrants in which Reactive Power flow is possible.

6.7.3 The meter pulses shall be made available to allow separate recording of the input and output Reactive Energy and Demand at each Connection Point.

6.8 Integrating Pulse Meters

6.8.1 To accommodate the operation of the Grid, Integrating Pulse Meters shall be provided at every Connection Point to record Active and Reactive integrated Demand data for use in billing and settlements for Energy services provided by the Grid and for transactions between Users.

6.8.2 All Integrating Pulse Meters shall be capable of electronic downloading of stored data or manual on-site interrogation by the Meter Operator.

6.8.3 All Integrating Pulse Meters shall have fail safe storage for at least two months of integrated demand data and be capable of retaining readings and time of day for at least two (2) days without an external power source.

6.9 Responsibility For Metering Installations

6.9.1 Respective generators shall own all generation Main Metering and the generators are responsible for ensuring that all such metering complies with the metering standards and requirements of this code. The Check Meter will be the responsibility of ZETCO.

6.9.2 All tariff metering at the Connection Point shall be the responsibility of ZETCO. In this case, ZETCO shall own the Main Meter and Grid User the Check Meter.

6.9.3 The provisions of the relevant interconnection agreement shall govern all metering at SAPP interconnection points.

6.9.4 Energy consumed by a generating station and drawn from ZETCO Grid shall be measured by tariff metering. Generators shall pay for this energy drawn through the station transformer from the gridGrid. The metering shall be connected on the HV side of the station transformer and shall belong to ZETCO.

6.9.5 ZETCO shall be responsible to ensure that all points identified to be metering points have metering installations.

6.9.6 ZETCO shall recover its costs for metering installation through connection charges.

6.9.7 ZETCO shall be responsible to manage and collect metering information for the Connection Point.

6.9.8 Parties connected or wanting to connect to the Grid shall provide the ZETCO with all information deemed necessary to enable performance of its metering duties.

6.10 Metering equipment standards

6.10.1 Voltage Transformers

6.10.1.1 The voltage transformers shall comply with the IEC 44 Standard or its equivalent national standard for metering, and should be of the 0.5 accuracy class. These voltage transformers shall be connected Wye- Wye with both star points grounded to a grounding Grid of acceptable resistance and shall provide a four-wire secondary connection.

6.10.1.2 The voltage drop in each phase of the voltage transformer connections of the same accuracy and class shall not exceed 0.2 V. It shall be connected only to a billing meter with a burden that shall not affect the accuracy of measurement.

6.10.2 Current Transformers

6.10.2.1 The current transformers shall comprise three units for a three-phase set, each of which complies with the IEC 44 Standard or its equivalent national standard for metering, and is of 0.5 accuracy class. It is preferred that two (2) current transformer cores with corresponding number of secondary coils per phase be provided, one connected to the Main Meter and the other to the Check Meter.

6.10.2.2 The current transformer's rated secondary current shall be either 1 or 5 amperes. The neutral conductor shall be effectively grounded at a single point. The current transformer shall be connected only to a billing meter with a burden that shall not affect the accuracy of measurement.

6.10.3 Meters

6.10.3.1 Meters shall be of the three-phase four wire type rated for the required site, comply with the appropriate IEC Standards or their

equivalent national standards, for static watt-hour meter and other types of meters, and be of the accuracy class of 0.2 or equivalent. The meters shall measure and locally display at least the kW, kWh, kVAR, kVARh, and cumulative Demand, with the features of time-of-use, maintenance records, and pulse output.

6.10.3.2 A cumulative record of the parameters measured shall be available on the meter. Bi-directional meters shall have two such records available. If combined Active Energy and Reactive Energy meters are provided, then a separate record shall be provided for each measured quantity and direction. The loss of auxiliary supply to the meter shall not erase these records.

6.10.3.3 For all metering installations, pulse output shall be provided for each measured quantity. The pulse output shall be from a three-wire terminal with pulse duration in the range from 40 to 80 milliseconds (preferably selectable) and with selective pulse frequency or rate. The minimum pulse frequency shall comply with the IEC Standard or its equivalent national standard, for the shortest integration period and the accuracy class of the meter. Pulse output shall be galvanically isolated from the voltage/current transformers being measured and from the auxiliary supply input terminals. The insulation test voltage shall be 1000 VAC, 50 Hz and applied for one minute.

6.10.4 Integrating Pulse Recorders

6.10.4.1 Integrating Pulse Recorders shall be capable of recording integrated Demand periods adjustable between fifteen (15) minutes and sixty (60) minutes.

6.10.4.2 Each recorder shall be capable of electronic data transfer through dedicated telephone lines or ZETCO's communication channels or manual downloading of data on-site.

6.10.4.3 The integrating pulse recorders shall provide a record for reference at a future time. The record shall be suitable for reference for a period of at least one year after it was generated. The integrating pulse recorder shall be regularly interrogated and the record shall also be maintained at the recorder for two (2) complete billing periods between one (1) interrogation or sixty (60) days, whichever is longer.

6.10.4.4 The time reference used with the Demand recorder shall ensure that the Demand period accuracy of this integrating pulse recorder is with a time error of no more than +/-1 second.

6.10.4.5 All revenue metering installations shall record time, based on the Central African standard time.

6.10.4.6 The start of each demand period shall be within +/-30 seconds of the standard time.

6.10.4.7 Reprogramming of integrating pulse recorders shall be done as soon as possible within one billing cycle if there is a time error.

6.11 Metering Equipment Testing And Maintenance

6.11.1 Instrument Transformer Testing

6.11.1.1 Test on the Instrument Transformers at the Connection Point, shall be done by ZETCO or a party authorized by ZETCO and the concerned User during the Test and Commissioning stage and then at least once every five (5) years or as the need arises due to queries on accuracy. The tests shall be carried out as specified in this Section of the Grid Code or an agreed equivalent international standard.

6.11.1.2 An Instrument transformer shall not be connected to a load beyond its rated burden and shall be operated at the optimum burden range to achieve maximum accuracy of the metering system. Burden Test shall be conducted during commissioning, re-installation or relocation or when requested by the User and/or the ZETCO. Loading resistors for compensating low burdens may be allowed as long as accuracy level is sustained.

6.11.2 Meter Testing and Calibration

ZETCO and the user shall test and seal the meters at least once a year and recalibrate or replace such meters if found to be outside the acceptable accuracy stipulated in the Grid Code.

6.11.3 Request for Test

6.11.3.1 A Grid User or ZETCO may request a test of the installed metering equipment if it has reason to believe that the performance of the Equipment is not within the accuracy limits set forth in clause 6.7.3 of this Grid Code . The test shall be done by the two concerned parties or an independent entity approved by both parties.

6.11.3.2 If the meter Equipment fails the test, ZETCO shall pay for the cost of the test. If the meter Equipment passes the test, the party who requested the test shall pay for the test cost.

6.11.4 Maintenance of Metering Equipment

6.11.4.1 The metering equipment at the Connection Point shall be maintained by ZETCO. All test results, maintenance programs, and sealing records shall be kept for the life of the Equipment. The Equipment data and test records shall be made available to authorized parties.

6.11.4.2 ZETCO shall repair the metering System as soon as practical and in any event within two (2) days if a metering System malfunctions or maintenance occurs. ZETCO shall be allowed to charge the metering services provided, subject to the approval of the ZERC.

6.11.5 Metering Equipment Security

ZETCO shall take all reasonable steps to prevent unauthorized interference with the Equipment. ZETCO shall provide seals and other appropriate devices to prevent unauthorized alteration on site settings and calibrations. The metering Equipment cubicle shall be completely and securely locked and sealed, provided any register on Equipment is visible and accessible. ZETCO shall also provide appropriate security against unauthorized access and against corruption of data in transmission.

6.12 Meter Reading And Metering Data

6.12.1 Integrating Pulse Metering Data

6.12.1.1 ZETCO shall download Integrating Pulse Metering data (the actual hourly data on generation and off-takes at each Connection Point) for billing and settlement purposes. Each User shall be provided full access to the data for his Connection Point.

6.12.1.2 The pulses from two or more meters may be combined into one integrating Pulse Recorder provided all the requirements of this Section of the Grid Code are met.

6.12.1.3 The meter pulses that need to be integrated into the recorder are:

(a) Active Energy and Demand incoming and outgoing in the Grid; and

(b) Reactive Energy and Demand incoming and outgoing in the Grid

6.12.1.4 Provisions shall be made by ZETCO to permit on-site as well as remote interrogation of the Integrating Pulse Recorder.

6.12.2 Running Total of Active Energy and Power

At input/output connections, the Active Energy and Active Power metering shall provide the running total of the Energy. Combined meters which measure both the Active Energy and Active Power input to and output from the Grid shall have the running totals available for each measured quantity, each direction, and each quadrant or combination of quadrants.

6.12.3 Running Total of Reactive Energy and Power

At input/output connections, the Reactive Energy and Reactive Power metering shall provide the running totals of the Energy. Combined meters which measure both the Reactive Energy and Reactive Power input to and output from the Grid shall have the running totals available for each measured quantity, each direction, and each quadrant or combination of quadrants.

6.12.4 Billing and Settlement Procedure

The billing procedures shall be as outlined in Service Levels Agreements and/or Power Purchase and Power Supply Agreements

6.13 Settlement Audit Procedure

6.13.1 Right to Request Settlement Audit

The User shall have the right to request an audit of the settlement data related to its account and the right to choose an independent third party qualified to perform the audit. ZETCO, Generators and Grid Users shall cooperate in the auditing process.

6.13.2 Allocation of Audit Cost

The external auditor has to be approved by all concerned parties. The requesting party is responsible for all outside auditor costs.

6.13.3 Audit Results

The audit results shall be issued to the billing party who shall issue a response to the audit report, including any adjustment in account billing/payments proposed.

6.13.4 Audit Appeals

If any User disagrees with the billing party's response to the audit, that response may be appealed to ZERC.

6.14 Confidentiality

Metering data and passwords are confidential information and shall be treated as such at all times.

7 References

The following standards shall be applicable as relevant to meters and associated equipment.

(i)	Electricity meters - class 0.5, 1 and 2 single-phase and poly-phase, single rate and multi-rate watt-hour meters.	BS 5685
(ii)	Insulation test for electric relays	IEC 255-5
(iii)	Alternating current static watt-hour meters for active energy (classes 0.25 and 0.5 S)	IEC 687
(iv)	Standard for Current Transformers	IEC 44
(v)	Standard for Voltage Transformers	IEC 44

SECTION 7

PROTECTION CODE

7.1 Introduction

This Section specifies the minimum protection requirements as well as typical settings, to ensure adequate performance of the power network as experienced by the customers. ZETCO shall at all times install and maintain protection installations that comply with the principles and specifications of this Section.

7.2 Objective

The objective of this Protection Code is to define the minimum protection requirements for any equipment connected to the Grid. The objective of the Protection Code is to define minimum protection requirements for any system or equipment connected to the Grid. This is done in order to:

- Ensure agreed power quality to customers
- Minimise damage to primary plant
- Prevent damage to healthy equipment that conducts fault current during faults
- Restore supply over the remaining healthy network
- Sustain stability and integrity of the power System
- Limit safety hazard to the power utility personnel and public.

7.3 General Principles

Protection schemes are generally divided into:

- Equipment protection and
- System protection.

The main functions of equipment protection are to selectively and rapidly detect and disconnect a fault on the protected circuit. The main function of System protection is to respond to a System condition as opposed to a System fault e.g. under frequency, voltage slide, out of step or sub synchronous resonance and undertake appropriate automatic actions to maintain power network integrity.

The protection functions are considered adequate when the protection relays perform correctly in terms of:

- Dependability
- Security

- Speed of operation
- Selectivity
- Sensitivity

All Grid users shall ensure correct and appropriate settings of protection to achieve effective, removal of faulty equipment within the clearance time specified in Section 7.6 of this Grid Code. Protection settings at the Connection Point shall not be altered, or protection bypassed and/or disconnected without consultation and agreement of ZETCO and the Grid User. In the case where protection is bypassed and/or disconnected, by agreement, then the cause must be rectified and the protection restored to normal condition as quickly as possible. If agreement has not been reached the electrical equipment will be removed from service forthwith.

ZERC shall monitor compliance to all matters covered by this section of the Grid Code and shall design and effect appropriate penalties for enforcing compliance.

7.4 Protection Coordination at the Connection Point

ZETCO shall be responsible for co-ordination of protection at the Connection Point and shall investigate any mal-function of protection or other unsatisfactory protection issues at the Connection Point.
Grid Users shall take prompt action to correct any protection mal-function.

7.5 Testing of Protection Equipment

ZETCO shall conduct periodic testing of equipment and systems to ensure these are performing to the designed specifications. Periodic tests must be performed within a period of two years. Each Grid User is responsible for tests on own equipment and test results shall be submitted to ZETCO. The tests are to be done as per the test procedures detailed under this Section of the Grid Code and as specified from time to time by ZETCO.

7.6 Fault Clearance Times

From a stability consideration the maximum fault clearance times for faults on any Grid User's system directly connected to the Grid, or any faults on the Grid itself, are as follows:

Allowable Maximum Clearance Times:

400 kV 100 milliseconds
330 kV 100 milliseconds
220 kV 100 milliseconds
132 kV 160 milliseconds
110 kV 160 milliseconds
88 kV 160 milliseconds
66 kV 160 milliseconds
33 kV 200 milliseconds
22 kV 200 milliseconds
11 kV 200 milliseconds

Higher voltages have generally faster clearance times because of the critical nature of such faults on the overall system. However, appropriate discrimination should be observed when protection settings are applied. Slower fault clearance times for faults on a Grid Users system may be agreed to but only if, in ZETCO's opinion, system conditions allow this.

7.7 Generator Protection Requirements

All Generating Units and all associated electrical equipment of the Generator connected to the Grid shall be protected by adequate protection so that the Grid does not suffer due to any disturbance originating from the Generating Unit. The minimum protection for the generators shall constitute the following:

- Overcurrent and Earth Fault
- Differential Protection
- Reverse power protection
- Overvoltage protection
- Negative phase sequence
- Field failure

7.8 Transmission Line (220- 400kV) Protection Requirements

Every Transmission line taking off from a Generating Station or a sub-station shall have Main and Back Up protection as mentioned below. ZETCO shall notify Grid Users of any changes in its policy on protection from time to time. Protection requirements for transmission differ slightly for short and long lines. For the purposes of this Grid Code short line are up to 5 km.

7.8.1 Transmission Line Protection Design Standard

On long lines the main protection shall be Distance Protection and on short lines (5km and below) it shall be Differential Protection or a combination of the two. Transmission lines shall be equipped with adequate protection systems, which include one or two discreet Distance Protection Relays (Main 1 and Main 2). Where Main 1 and Main 2 protection systems are installed and where practicable, these shall be designed to operate independently of the other. The relays should be connected to separate measuring transformers and auxiliary supplies fused separately.

The minimum requirement for the protection of the protected line is three forward zones. Zone 1 should normally be 80% of the protected line and zone 2 and zone 3 should be 120% and 150% 0f the protected line respectively. Zone 2 covers 100% of the protected line and 20% of the next shortest adjacent line. Zone 3 covers 100% of the protected line, 50% of the next adjacent shortest line and should have 15% reverse reach on the protected line.

The Distance Protection should also operate on different schemes – (permissive over-reach and permissive under-reach). Directional Earth Fault protection shall be incorporated in the Distance Protection Relays or installed as a separate relay to provide more sensitive protection against high impedance Earth Faults. Back up over-current and Earth Fault protection shall be installed.

Short feeders should be equipped with line Differential Protection Relays in addition to all the other protection to improve performance for high resistance faults.

7.8.2 Automatic Re closing (ARC) On Transmission Lines

The most important consideration in the application of automatic re closing (ARC) on transmission lines is the maintenance of system stability and synchronism. Automatic re closing is initiated following Zone 1 operation of the Distance Protection Relay and subsequent tripping of the circuit breaker for a fault on the line.

ARC sequence will comprise a single phase High Speed Auto Re closing (HSAR) followed by three phase Delayed Auto Re closing (DAR) if necessary. Note that for three phase fault only the delayed auto re closing should be initiated

7.8.3 Power Swing Blocking

Power swings are variations in power flow which occur when the voltage of generators at different points of the power system slip relative to each other to cater for changes of load magnitude and direction or as a result of faults and their subsequent clearance. The result of a power swing may cause the impedance presented to a distance relay to move into the relay-operating characteristic. In the case of a transient power swing, it is important that the distance relay should not trip and should allow the power system to return to a stable condition.

Most distance relays on the transmission system have an optional power swing-blocking feature available. ZETCO will ensure that this feature is enabled for the Transmission lines.

7.9 Sub transmission (132kV and below) Lines

Sub Transmission feeders shall be protected by a single Distance Protection. Sub Transmission lines protection shall consist of main and back up protection. Main protection shall be a single Distance Protection Relay consisting of three forward zones. The zones are as per Section 7.8.1 of this Grid Code. Back up shall be provided by definite time and inverse definite minimum time (IDMT) Over-Current and Earth Fault Relays. Short feeders should be equipped with additional differential Relays to provide more sensitive protection for high impedance faults. High-speed auto re closing is deemed necessary for stability purposes. However, most sub transmission lines are radial and less critical to system stability. Sub Transmission lines therefore do not necessarily need HSAR, unless specified by ZETCO. Three phase delayed Auto Re Closing should therefore be employed on zone 1 faults on the sub transmission system for all faults.

7.10 Distribution Line Protection Requirements:

For the purposes of this Grid Code, Distribution shall refer to all Connection Points at 33kV and below. All 33 kV and 11 kV lines at Connection points shall be provided with a minimum of Over Current and Earth Fault protection with or without directional features as given below.

7.10.1 Plain Radial Feeders:

Non-directional time lag Over Current and Earth Fault Relay with suitable settings to obtain discrimination between adjacent relay stations.

7.10.2 Parallel Feeders/ Ring Feeders:

Directional time lag Over Current and Earth Fault Relays.

7.10.3 Long Feeders/Transformer Feeders

For long feeders (above 5 km) or transformer feeders, the Over Current Relays should incorporate a high set instantaneous element.

7.11 Transformer Protection Requirements:

7.11.1 Generating Station/ Transmission System

All windings of Auto Transformers and power transformer of EHV class shall be protected by differential and Balanced Earth Fault (BEF)/ Restricted Earth Fault (REF) Relays. In addition there shall be back up time lag Over Current and Earth Fault protection. For transformers operating in parallel, Back up Over Current and Earth Fault protection shall have a directional feature at the Connection Point. Over Current Earth Fault The Over Current Relays should incorporate a high set instantaneous element. In addition to electrical protection, gas operated relays, winding temperature protection and oil temperature protection shall be provided.

7.11.2 Distribution system at Connection Point

For smaller transformers of HV class on the Distribution System Differential Protection shall be provided for 10 MVA and above along with back up time lag Over Current and Earth Fault protection (with directional feature for parallel operations).
Transformers of 1.6 MVA and above and less than 10 MVA shall be protected by time lag Over Current, Earth Fault and instantaneous REF relays. In addition all transformers of 1.6 MVA and above shall be provided with gas-operated relays, winding temperature and oil temperature protection.

7.12 Sub- Station Bus Bar Protection

All Users shall provide adequate bus zone protection for substation bus bars in all 220 KV substations to 400kV substations.

7.13 Teleprotection Requirements

7.13.1 Introduction

Tele protection is used in the ZETCO network as part of the overall protection schemes associated with High Voltage networks in order to achieve fast and selective fault clearances indipendent of the fault location and system conditions.
Teleprotection relays are positioned between the station protection relays and the Power Line Carrier Equipment to receive and send inter tripping signals between substations.

7.13.2 Characteristics of Teleprotection

Important criteria for protection signalling equipment are security, dependability and transmission time.

7.13.3 Teleprotection Schemes

7.13.3.1 Direct Transfer Trip (DTT)

Transfer Tripping shall be applied on all substations and transmission lines with Distance Protection schemes at both ends and for busbar protection scheme. DTT shall be set to operate for Distance Protection zone 1 operation. Receipt of the signal at the remote end initiates the tripping immediately at this end.

7.13.3.2 Permissive Under Reach Transfer Trip (PUTT)

PUTT shall be set to operate for under reaching Zone 1 elements of the Distance Protection Relay operation, trip the associated breaker and send an inter trip signal to the remote end. Receipt of the carrier signal and the operation of the zone 2 elements cause an instantaneous trip of the breaker at this end. The scheme shall afford fast fault clearance for faults occurring at the ends of the line

7.13.3.3 Permissive over reach Transfer Trip (POTT)

POTT shall be set to operate for the over reaching zone 2 elements of the Distance Protection, trip the associated breaker and send an inter trip signal via the tele protection relay to the remote end. Receipt of the carrier signal and the operation of the over reaching Zone 2 elements at this end causes an instantaneous trip of the breaker at this end. The scheme shall afford fast clearance of faults in the zone 2 part of the protected lines.

7.13.3.4 Blocking Schemes

Blocking schemes shall be applied where the Distance Protection Relay zone 3 Reverse looking elements are used to block instantaneous tripping of the remote relay for Zone 2 faults external to the protected line section. In this scheme, signalling is only initiated only for external faults and signalling transmission takes place over healthy line section. Fast fault clearance occurs when the signal is received and the over reaching zone 2 elements looking into the line operate.

7.14 Over voltage Protection

Over voltages in the system are caused by lightning surges, switching surges and sudden load throw off. Over voltage surges cause possible failure of insulation on transformers, motors and other related electrical equipment.
They also cause possible flashovers on highly stressed points external or internal of to equipment.

7.14.1 Protection against Lightning Over voltages

This shall be achieved through the following;

7.14.1.1 Rod Gaps

These shall be applied across insulator string or bushing insulators.The gap shall be set to allow the breakdown of the insulation medium at voltages above 140% of nominal as specified in the ZETCO's Parameter Guidelines for Protection Test Document Number PTOR 020 R 00.

7.14.1.2 Horn Gaps

These shall be applied above overhead lines or substations to provide effective protection against direct strike on line conductors, towers and substation equipment. All sub transmission and transmission overhead lines shall be provided with Horn Gaps. Horn Gaps shall be set to provide effective protection against direct strikes on line conductors, towers and substation equipment as specified by ZETCO.

7.14.1.3 Lightning Masks

These shall be applied above buildings to protect them against direct lightning strikes. All substation buildings shall be provided with lightning masks for protection against direct lightning strikes. The lightning masks shall be designed as specified by ZETCO.

7.14.1.4 Surge Arrestors

These shall be applied on lines terminating at the substations and on the transformer terminals so that they divert over voltages to earth without causing short circuits. The surge arrestors shall be as specified by ZETCO.

7.15 Protection Against Switching Surges at the Connecting Point

7.15.1 Where it is recommended through studies, shunt reactors and or pre-closing resistors on circuit breakers shall be installed to protect against switching surges.

7.15.2 All distribution circuits at the Connection Point shall be equipped with surge suppressors and arrestors to limit over voltages.

7.16 Protection of Compensating Equipment

7.16.1 Protection of Reactors

All reactors shall be protected at the minimum, by Over Current and Earth Fault Protection, Differential Protection, Restricted Earth Fault Protection, Gas operated and temperature relays.

7.16.2 Protection of Capacitors

All Capacitors shall be protected by a minimum of Over Current and Earth Fault Relays.

7.16.3 Protection of Static Var Compensators

All Static Var Compensators shall be protected by Over Current and Earth Fault Relays.

7.17 Under frequency Load Shedding

ZETCO shall employ an automatic Load Shedding scheme when frequency falls to 48.8 HZ and below. The Load Shedding scheme shall be in stages as follows:

7.17.1 Stage 1 is set at 48.8 Hertz and disconnects a total of 20% of the demand

7.17.2 Stage 2 is set at 48.5 Hertz and disconnects a total of 10% of the demand

7.17.3 Stage 3 is set at48.2 Hertz and disconnects a total of 10% of the demand

7.17.4 Stage 4 is set at 47.5 Hertz and disconnects most of the remaining loads leaving essential services.

7.18 Safety Protection Requirements

7.18.1 Fire Protection

All electrical energised equipment is capable of causing fire if proper usage and handling procedures are not adhered to.

All ZETCO substations and Connection Points should be equipped with appropriate electrical fire extinguishers located at strategic points at each substation. These shall be tested on annual basis.

Fire fighting system shall where appropriate be automatic and in all instances be adequate. The system shall be a combination of fire alarm system and transformer water spray system. The system shall be tested annually.

All the Power Transformers in a substation deemed critical by ZETCO shall be equipped with water spray system (mulsifire protection).

The transformers in the switchyard shall be provided with barrier walls. The walls shall be covered with refractory bricks. The wall shall prevent the spreading of fire from one transformer to another.

Fireguards should be created and maintained around the perimeter of every substation and connection point.

All fuels capable of causing fire such as petrol and diesel should be stored at sites away from electrical plant in every substation and Connection Point.

Adequate precautions shall be taken and protection shall be provided against fir hazards to all indoor equipment.

7.18.2 Personnel Protection

All personnel that have to carry out any works at the Connection Point or ZETCO Substation shall abide by the ZESA Safety Rules and any other Safety requirements that shall be put in place by ZETCO from time to time. As a protection measure to personnel against electrical hazards the following shall be observed at all times.

7.18.3 Visitors

Visitors to a Connection Point or ZETCO Substation
All visitors to the Connection Point or ZETCO substation shall obtain the relevant authority to enter and sign the Visitor's Live Enclosure Permit before entering.

7.18.4 Equipment Switching

All switching in the Connection Point or ZETCO substation shall be carried out by a ZETCO Senior Authorised Person under the recorded Instruction of a ZETCO Controller.

7.18.5 Carrying out Works at the Connection Point

All works at the Connection Point or any part of the ZETCO Network shall be carried out under any of the following ZESA Safety Documents or any document that shall be specified by ZETCO from time to time, depending on the nature of works being carried out.

- Limitation of Access Document
- Permit to Work Document
- Live Line Permit to Work Document
- Sanction for Test Document

7.19 Earthing Requirements For Substations

7.19.1 Earthing Systems

All substations Earthing Systems should have Earth Resistance lower than 0.5 ohms for effective discharge of lightning or over voltages to earth.

The current carrying paths of an Earthing System should have enough capacity to deal with maximum fault current

Earthing Mat shall be provided below ground level and earth electrodes shall be driven into ground at several points and shall be connected to the Earthing Mat to form an Earthing Mesh.
All structures, transformer tanks, breakers, equipment panels shall be connected to this mat by galvanised steel strips.

7.19.2 Periodic Checks on Earthing Systems

7.19.2.1 Buried elements of the earthing system should be checked for condition at random points as and when necessary but not exceeding a period of five (5) years.

7.19.2.2 Circuit continuity should be checked between earthing devices and earthed elements. Open circuits and high resistance connections should be investigated and rectified when regular maintenance is being carried out.

7.19.2.3 Earthing resistance should be measured and if more than 0.5 ohms, it should be reduced by the addition of any of the following;

- Sodium Chloride (Common Salt)
- Calcium Chloride
- Sodium Carbonate
- Copper Sulphate
- Charcoal
- Soft Coke

7.20 Test and Commissioning Procedures

Test and Commissioning Procedures shall be carried out in accordance with the ZETCO standards as specified in the following documents:

7.19.1	Guidelines for Power Systems Protection and Control	- PROT 001 R00
7.19.2	Transformer Protection Planned Maintenance Procedure	- PROT 002 R00
7.19.3	Transformer Protection Planned Maintenance Instructions	- PROT 003 R00
7.19.4	Transformer Protection Planned Maintenance Records	- PROT 004 R00
7.19.5	Feeder Protection Planned Maintenance Procedure	- PROT 005 R00
7.19.6	Feeder Protection Planned Maintenance Instructions	- PROT 006 R00
7.19.7	Feeder Protection Planned Maintenance Records	- PROT 007 R00
7.19.8	Transformer Protection Commissioning Procedure	- PROT 008 R00
7.19.9	Transformer Protection Commissioning Instructions	- PROT 009 R00
7.19.10	Transformer Protection Commissioning Records	- PROT 010 R00
7.19.11	Feeder Protection Commissioning Procedure	- PROT 011 R00
7.19.12	Feeder Protection Commissioning Instructions	- PROT 012 R00
7.19.13	Feeder Protection Commissioning Records	- PROT 013 R00
7.19.14	Generator Protection Planned Maintenance Procedure	- PROT 014 R00
7.19.15	Generator Protection Planned Maintenance Instructions	- PROT 015 R00
7.19.16	Generator Protection Planned Maintenance Records	- PROT 016 R00
7.19.17	Generator Protection Commissioning Procedure	- PROT 017R00
7.19.18	Generator Protection Commissioning Instructions	- PROT 018R00
7.19.19	Generator Protection Commissioning Records	- PROT 019R00
7.19.20	Parameter Guidelines for Protection Tests	- PROT 020 R00

7.21 Data Requirements:

Grid Users shall provide ZETCO with all data concerning Protection in their system that is connected to the Grid for as specified in Section 8 of this Grid Code.

SECTION 8

INFORMATION EXCHANGE CODE

8.1 Introduction

The Information Exchange Code defines the reciprocal obligations of parties with regard to the provision of information for the implementation of the Grid Code.

The information requirements are necessary to ensure non-discriminatory access to the Transmission System and the safe, reliable provision of transmission services.

The information requirements are divided into planning information, operational information and post-dispatch information.

Information criteria specified in the Information Exchange Code are supplementary to the other codes within the Grid Code.

8.2 Information exchange interface

The parties shall identify the following for each type of information exchange:

- The name, designation and contact details of the person(s) designated by the information owner to be responsible for provision of the information
- The names, contact details of, and the parties represented by persons requesting the information
- The purpose for which the information is required.

8.3 Confidentiality of information

8.3.1 Information exchanged between parties governed by this code shall be confidential.

8.3.2 Confidential information shall not be transferred to a third party without the written consent of the information owner. Parties shall observe the proprietary rights of third parties for the purposes of this code. Access to confidential information within the organisations of parties shall be provided as reasonably required.

8.3.3 Parties receiving information shall use the information only for the purpose for which it was supplied.

8.3.4 The information owner may request the receiver of information to enter into a confidentiality agreement before information, established to be confidential, is provided. A pro forma agreement is included in Appendix II.

8.3.5 The parties shall take all reasonable measures to control unauthorized access to confidential information and to ensure secure information exchange. Parties shall report any leak of information that is governed by a confidentiality agreement as soon as practicable after they become aware of the leak, and shall provide the information owner with all reasonable assistance to ensure its recovery or destruction (as deemed appropriate by the information owner).

8.4 Telephone/Fax

The Grid User and ZETCO shall be responsible for the provision and maintenance of no less than one telephone and one fax unit that shall be reserved for operational purposes only, and shall be continuously attended to and answered without undue delay.

ZETCO shall use a voice recorder for historical recording of all operational voice communication with Grid Users. These records shall be available for at least one (1) year. ZETCO shall make the voice records of an identified incident in dispute available within a reasonable time after such a request from the Grid User and/or ZERC.

8.5 Electronic Mail

Electronic communication, wherever used shall always be supported by signed hard copies. The data should be in the same format as specified for hard copy transmission.

The exchange of archived data shall preferable be carried out on a computer-to-computer basis communication link.

8.6 System planning information

8.6.1 Grid Users shall provide such information as and when requested by ZETCO for the purposes of planning and developing the Transmission System. The parties shall submit the information to ZETCO without undue delay. Such information may be required so that ZETCO can plan and develop the Transmission System, monitor current and

future power system adequacy and performance, and fulfill its statutory or regulatory obligations.

8.6.2 Grid Users shall submit to ZETCO and to all relevant service providers the relevant information listed in Appendix I or as specified by ZETCO from time to time.

8.6.3 ZETCO may request additional information as and when required.

8.6.4 ZETCO shall keep an updated technical database of the System for purposes of modelling and studying the behavior of the Transmission and Sub-transmission Systems.

8.6.5 ZETCO shall provide Grid Users or potential Grid Users , upon any reasonable request, with any relevant information that they require to properly plan and design their own networks/ installations or comply with their other obligations in terms of the Grid Code

8.6.6 ZETCO shall make available all the relevant information related to network planning as described in the Grid Connection Code, Section 2 of this Grid Code.

8.6.7 Customers shall, upon request to upgrade an existing connection or when applying for a new connection provide ZETCO with information relating to the following:

Table 8.6 System Planning Requirements for Customers

Commissioning	Projected or target commissioning test date
Operating	Target operational or on-line date
Reliability of connection requested	Number of connecting circuits, e.g. one or two feeders, or firm/non-firm supply required
Location map.	Upgrades: name of existing point of supply to be upgraded and supply voltage New connections: provide a 1:50 000 or other agreed scale location map, with the location of the facility clearly marked. In addition, co-ordinates of the point of connection to be specified
Site plan	Provide a plan of the site (1:200 or 1:500) of the proposed facility, with the proposed point of supply, and where applicable, the transmission line route from the facility boundary to the point of supply, clearly marked
Electrical single-line diagram	Provide an electrical single-line diagram of the Grid User's intake substation and to provide an accurate record of the layout of circuits, numbering and nomenclature of equipment and plant.

8.6.8 ZETCO may estimate any System planning information not provided by the Grid user. ZETCO shall take all reasonable steps to reach agreement with the Grid User on estimated data items. ZETCO shall indicate to the Grid User any data items that have been estimated. The obligation to ensure the correctness of data remains with the Grid User.

8.6.9 Generators shall submit to ZETCO all the maintenance planning information detailed in Section 5 of this Grid Code with regard to each unit at each power station.

8.7 Operational information

8.7.1 Pre- commissioning studies

8.7.1.1 Customers shall meet all system planning information requirements before the commissioning test date. (This will include confirming any estimated values assumed for planning purposes or, where practical,

replacing them with validated actual values and with updated estimates for the future.)

8.7.2 Commissioning and notification

(a) Records of commissioning shall be maintained for reference by the asset owner for the operational life of the plant and shall be made available, within a reasonable time, to ZETCO upon notification of such request.

(b) The asset owner shall communicate changes made during an outage to commissioned equipment, to ZETCO before the equipment is returned to service. ZETCO shall keep commissioning records of operational data for the operational life of the plant connected to the Transmission System.

(c) Participants shall give ZETCO notice, as defined in the Operations Code, of the time at which the commissioning tests will be carried out.

8.7.3 General information acquisition requirements

8.7.3.1 Supervisory Control and Data Acquisition (SCADA)

The information exchange shall support data from the SCADA system. The System Operator shall be able to monitor the state of the power system using the data from the remote terminal units (RTU).

The SCADA system shall be used for storage, display and processing of operational real time data. All Grid Users and Generating Units shall make available outputs of their respective operational equipment to the data acquisition system or as specified in the connection agreement.

The data collection, storage, monitoring and display center for ZETCO SCADA data shall be The National Control Center.

8.7.3.2 Generation Operational SCADA data

The Generator Unit shall provide operational information for both real time and recording purposes in relation to each Generating Unit at each Power Station in respect of indications and measurands as follows:

i. Mwhr
ii. Voltage
iii. Frequency
iv. MW
v. MVAr
and any other additional data as specified in the connection agreement.

8.7.3.3 Transmission System Operational SCADA data

ZETCO and the grid user shall specify the data characteristics for monitoring electrical supply and load characteristic at each sub-station and connection point. The data shall be used for both real time and recording purposes in relation to each feeder, transformer and compensation device in respect of indications and measurands as follows:

i. Voltage
ii. Frequency
iii. MW
iv. MVAr
v. Current
and any other additional data as specified in the connection agreement.

8.7.3.4 Process signals interface to RTU

The interface of the process signals to RTU shall be as specified by ZETCO. The Interface cabinets shall be installed in the Grid users plant and equipment room if required. The provision and maintenance of the wiring and signalling from the Grid Users plant and equipment to the interface cable to MDF shall be the responsibility of the Grid User.

8.7.4 Measurements and indications to be supplied by Grid Users to ZETCO shall include the formats as specified by ZETCO. Where required signals become unavailable or do not comply with applicable standards

for reasons within the control of the provider of the information, such participant shall report and restore or correct the signals and/or indications as soon as reasonable.

8.7.5 ZETCO shall notify the Grid User, where ZETCO, acting reasonably and in consultation with the Grid User , determines that additional measurements and/or indications in relation to a Grid User plant and equipment are needed to meet a Transmission System requirement. The costs related to the participant's modifications for the additional measurements and/or indications shall be for the account of the providing Grid User

8.7.6 On receipt of such notification from ZETCO the Grid User shall promptly ensure that such measurements and/or indications are made available at the RTU.

8.7.7 ZETCO and the Grid User shall agree on the timeous provision of operational data items as per the relevant Power Purchase Agreement and/or Power Supply Agreement.

8.7.8 Grid Users shall jointly verify all measurements and/or indications for functionality and accuracy once every three (3) years, so as to achieve overall accuracy of operational measurements within the limits agreed.

8.7.9 The data formats to be used and the fields of information to be supplied to ZETCO by the Grid Users shall be as per the Power Purchase Agreements.

8.7.10 ZEDC shall provide periodic feedback to Grid Users regarding the status of equipment and systems installed in the substations where they are connected to the Transmission System. The feedback shall include results from tests, condition monitoring, inspections, audits, failure trends and calibration. The frequency of the feedback shall be determined in the operating agreement, but will not exceed one year.

8.7.11 Plant status reports provided by Grid Users will also include contingency plans where applicable.

8.8 Unit Scheduling

8.8.1 Declared Available Capacity

Generators shall complete and submit to ZETCO the Declared Available Capacity for each generating unit at a period specified by ZETCO under the Power Purchase Agreement. All scheduled and other outages and deratings which prevent some or all of the Dependable Capacity of each unit from being available for dispatch shall be specified. Should the Declared Available Capacity be less than the Dependable Capacity for any generating unit due to a reason other than Scheduled Outage, ZPC or any other generator shall explain the reason for the reduction, the action planned to restore the unit to

the Dependable Capacity level, and the estimated time required for such restoration.

8.8.2 Statement of Reduction and Re- establishment in Declared Available Capacity

8.8.2.1 Should the ZPC or any generator become aware of a change in status of any generating units following the submission of the Declared Available Capacity it shall make this status change known immediately to ZETCO by telephone, followed by written confirmation to be received by ZETCO within one hour. ZPC or any other generator shall confirm the reduction in Declared Available Capacity, the reason for the reduction, the action planned to restore the Declared Available Capacity to the Dependable Capacity level, and the estimated time required for such restoration.

8.8.2.2 Once the Declared Available Capacity can be increased over the levels stated under 8.5.1 this change in status shall immediately be relayed to ZETCO by telephone communication, followed by written confirmation to be received by ZETCO within one hour. ZETCO may then dispatch the affected generating unit at the Declared Available Capacity level.

8.8.3 Scheduled Capacity Requirement

8.8.3.1 ZETCO will notify ZPC or any other generator of its Scheduled Capacity requirements for the plant for each hour of the day as per Power Purchase Agreement ZPC or any other generator will confirm acceptance and dispatch the plant to the Capacity Schedule specified in the Power Purchase Agreement.

8.8.3.2 Should ZETCO require changing the Scheduled Capacity level of the plant at any time, it shall notify ZPC or any other generator of all changes through telephone communication, followed by sending a revised schedule to be received by ZPC or any other generator within one hour. ZPC will dispatch the plant to the revised Scheduled Capacity requirements as notified by the initial telephone communication.

8.9 Demand Scheduling

ZETCO reserves the right to load shed should circumstances beyond its control arise. This will be done to ensure system integrity. ZETCO shall as soon as possible give notice of any imminent load shedding that might arise due to plant outages due to maintenance. However for forced outages such notices might not be possible

8.10 Data storage and archiving

The obligation for data storage and archiving shall lie with the information owner.

8.10.1 The systems that store the data and/or information to be used by the parties shall be of their own choice and for their own cost.

8.10.2 All the systems must be able to be audited by the ZERC.

8.10.3 The systems must provide for clear and accessible audit trails on all relevant operational transactions. All requests that require an audit on a system shall be undertaken with reasonable notice to the parties.

8.10.4 The information owner shall keep all hard copy and/or paper-based information for a period of at least five (5) years (unless otherwise specified in the Grid Code) commencing from the date the information was created.

8.10.5 Parties shall ensure reasonable security against unauthorised access, use and loss of information (i.e. have a backup strategy) for the systems that contain the information.

8.10.6 Parties shall store planning information that is kept electronically for at least five (5) years or for the life of the plant or equipment concerned, whichever is the longer.

8.10.7 ZETCO shall archive operational information, in a historical repository sized for three (3) years' data. This data includes transmission time-tagged status information, change of state alarms, and event messages, hourly scheduling and energy accounting information and operator entered data and actions.

8.10.8 An audit trail of all changes made to archived data should be maintained. This audit trail shall identify every change made, and the time and date of the change. The audit trail shall include both before and after values of all content and structure changes.

8.11 File Transfers

The format of the files used for data transfer shall be negotiated and defined by the supplier and receiver of the information. The file transfer media shall be negotiated and defined by both parties involved. The parties shall keep the agreed number of files for backup purposes so as to enable the recovery of information in the case of communication failures.

8.12 Performance data

8.12.1 Generator performance data

8.12.1.1 Generators shall provide ZETCO monthly with performance indicators in relation to each unit at each power station in respect of availability and reliability as determined from time to time by ZETCO.

8.12.1.2 Generators shall report significant events, such as catastrophic failures, to the ZERC within one (1) week of occurrence of such event.

8.12.2 ZEDC and End- Use Customer Performance

8.12.2.1 The performance measurement of all distributors and end-use customers shall be supplied to the ZETCO in accordance with the operating agreement requirements.

8.12.2.2 Distributors shall submit on annual basis the maximum demand of each distributions substation to facilitate long term network development by ZETCO

8.12.2.3 Distributors shall submit on annual basis any known load exceeding 3MVA to be connected to the distribution system and the substation where such loads are likely to be connected

8.12.2.4 Distributors shall report periodic testing of under-frequency load shedding relays in the following format:

TABLE 8.7.2: Testing of Under- Frequency Load Shedding Relays

Date: Substation: Fed from transmission substation (directly or indirectly):				
	Activating frequency		**Timer setting**	
	Required	**As tested**	**Required**	**As tested**
Stage 1				
Stage 2				
Stage 3				
Stage 4				
	Feeders selected (required)		**Feeders selected (as tested)**	
Stage 1				
Stage 2				
Stage 3				
Stage 4				

8.12.3 Performance

ZETCO shall make the following Transmission System performance indicators available monthly to the ZERC:

Table 8.12.3 ZETCO Performance Indicators to be submitted to ZERC

Indicator	Performance this month		Performance year to date		Current international performance where applicable
	Actual	Targeted	Actual	Targeted	
Local generation by plant					
Imports by source					
Energy purchased from IPPs and embedded generators by source					
Inadvertent energy					
Exports					
Capacity arising from demand side management					
Power wheeled					
Energy at Bulk Supply Point					
Energy Sold to ZEDC					
System maximum demand					
System load failure					%
Transmission and sub-transmission losses (separate)					
System minutes					
Transmission system minutes					
Number of supply interruptions					
Average duration of interruptions (minutes)					
Number of frequency excursions outside statutory limits					
Number of voltage excursions outside statutory limits					

% of transmission line faults resulting in supply interruptions					
% of sub-transmission faults resulting in supply interruptions					
% of transmission/sub-transmission transformer resulting in supply interruption					
Number of supply interruption by cause (human error, lightening, bush fires, other)					
% of transmission/sub-transmission substation operated at full capacity					
% of lines operated at thermal rating					
Unsaved energy attributed ZETCO					
Average defects duration					
Planned maintenance done (%)					
Number of supply interruption due to protection malfunction					
Availability of protection system (%)					
Number of power control system failures					
Power system communication availability (%)					
Sales Revenue/Employee					
Gwh/employee					
Number of employees per category (managerial, technical etc)					
Number of non-fatal accidents					
Number of fatal accidents					
Number of environmental					

complaints					
Number of customer complaints					
Itemized Revenue and Expenditure as per format provided by ZERC					
Average processing time for application					
Average time for system studies					
Average Connection time after system studies and payment of Connection Fees					
Number of customers awaiting connection due to transmission and sub transmission constraints					
Average waiting time by customers awaiting connection due to ZETCo constraints					
Average time for responding to written correspondence by customers					
Network length by voltage level					
Number of transformers by voltage level and capacity					
Average transformer life					
Average line life					
Annual system chronological data					
Any other statistics or indicators that would be specified by ZERC from time to time					

SECTION 9

PROJECT APRAISAL FRAMEWORK CODE

9.1 Introduction

The purpose of this code is to provide guidance on how to appraise projects in ZETCO to ensure that only projects that satisfy ZETCO 's viability criteria are implemented.

This edition of the appraisal framework unlike the previous edition includes project documentation guidelines and guidelines on the economic and financial analysis of projects to determine whether projects will increase shareholder value/wealth or not. The underlying principles are that:

i) Money received today can be invested to earn more money at a real rate of interest.
ii) Inflation erodes purchasing power of money such that money received in the future does not buy the same quantity of goods as money today.
iii) There is risk that money expected in the future might not be received. This is called default risk.
iv) There is the risk that the investors might not be able to liquidate the investment into cash at a fair market price. This is called liquidity risk

The proper carrying out of a project appraisal will ensure that the proper opportunity cost of public money will be undertaken in an environment where projects are competing for scarce public funds.

9.2 Project Documentation Guidelines

These guidelines are meant to provide guidance on areas to include when writing up project proposals to ensure that there is clarity and uniformity in presentations. The guidelines preseted here are the minimum requirements and are not exhaustive as projects always vary according to what they are meant to address. It is however felt that some of the major topics for any project are covered. Any relevant additional information that helps better the proposal can still be included.

9.2.1 Project Justification

The project justification should include:

- Purpose of the project
- Nature of the project: Either new works, reinforcement/rehabilitation, replacement or expansion
- How the project is going to fit into the infrastructure already in place and future plans
- Corporate strategic issues the project meant to address
- Identification of the needed service or measures to solve the problems being presently encountered
- Identification of options to provide the needed service. Here the planner must provide the full portfolio of available options
- Evaluation of criteria for evaluating options (e.g. reserve margin, voltage limits)
- Analysis of options considering technical, economic, financial and environmental impacts
- Analyzing availability of resources in ZETCO - labour (local skills, expatriate skills), training; financial resources (local and foreign), physical (land, buildings). Any other possible constraints to be addressed here.
- A recommendation to commit resources to the plan, which provides the needed service in the most cost-efficient manner possible, and which balances the interests of customers and ZETCO.
- For the chosen alternative it is necessary to ensure that the costs are current. If any price changes are foreseen (before approval of project) it may be necessary to include a conservative (+-10%) price change contingency.
- Cost – Benefit analysis (Identification of benefits flowing out of the inception of such projects

A simple procedure to identify benefits of projects should involve answering the following questions:

- ☞ What is the problem to be addressed?
- ☞ How is the problem being addressed now? - status quo
- ☞ What costs are associated with the status quo, which would not be incurred with the inception of the project? - These become the benefits or costs saved.

9.2.2 Results of cost/benefit analysis

9.2.2.1 A brief outline of the results of the financial and economic analysis of the recommended least cost option (as carried out in compliance to the procedures set in Section 3.3 of this Grid Code) shall be contained in the project documentation.

9.2.2.2 The project documentation shall contain a comment on whether the project passes the set approved viability criteria.

9.2.2.3 Projects shall be subjected to sensitivity analysis and the results of such a sensitivity analysis shall constitute project documentation

9.2.3 Conclusions and recommendations

The project documentation shall provide specific recommendation made by the initiator of the proposal, on how the project shall be implemented. Such a recommendation shall have an alternative fall back plan.

9.3 APPRAISAL GUIDELINES

9.3.1 Economic Analysis

9.3.1.1 Purpose

Main purpose of carrying out economic project appraisals to ensure that scarce resources are used to the best advantage of ZETCO and the country in terms of meeting adequate, safe, reliable, environmentally friendly and least cost energy supplies.

9.3.1.2 Underlying Principles

Economic analysis shall be based on **real prices** with a view to secure maximum benefit to the society as a whole rather than the utility. In general, all domestic transfers like indirect taxes, duties, and interest on loans, loan repayment, depreciation and subsidies shall be excluded in prices used in economic analysis. Apart from the exclusion of transfers, the economic analysis shall make use of shadow pricing, which corrects for the distortions existing in the market. Such shadow prices shall be for foreign exchange, labour and the discount rate.

9.3.1.3 Cost Parameters

9.3.1.4 The cost shall be calculated on an incremental basis, which means that **sunk costs** should be excluded. Sunk costs are costs already incurred before the analysis of the project.

9.3.1.5 The costs should be based on standard prices. The prices shall be availed to any user or ZERC

9.3.1.6 Investment or Capital Costs

For projects the capital costs shall be split into two categories, namely **foreign and local costs**.

9.3.1.7 Foreign costs require use of foreign currency to acquire the project inputs (materials, labour & transport), and local costs (also materials, labour & transport) require the use of local currency.

9.3.1.8 Foreign costs shall be shadow priced by the shadow price of foreign currency, whilst the labour component shall be further shadow priced by the labour adjustment factor.

9.3.1.9 Costs quoted in foreign currencies shall be converted to local currency using the ruling exchange rate at the time of analysis and the assumptions used shall be made available to ZERC and any other User.

9.3.1.9.1 Unless prices are expected to increase before actual implementation (in which case a price contingency would have to be included), no conversion or adjustments are required for these costs.

9.3.1.10 Total capital or investment costs shall be obtained by adding the foreign and local portions of costs.

9.3.2 Operation and Maintenance Costs

Annual O & M costs shall be assumed to be 1.5% of capital costs. They shall be obtained by multiplying the total capital investment costs by 1.5% for the lifetime or period of analysis of the project. However where actual figures can be obtained use should be made of them in place of this assumption.

9.3.3 Electricity Production Cost

The electricity production cost includes cost of generation, and relevant cost on the transmission, sub-transmission and distribution network. These shall be obtained by multiplying the units or kWh generated by the average electricity production costs applicable to the voltage level.

Discount Rates

These shall as stipulated by Government from time to time

9.3.4 Opportunity Costs

Any opportunity costs or loss of revenue due to the implementation of a project must be taken into account during economic analysis. The loss in revenue must be included in the analysis for the project life.

9.3.5 Transfer Payments

Sales tax, custom duties, income tax, subsidies and interest on borrowed funds are all regarded as transfer payments in economic analysis and should therefore be ignored as they do not represent direct claims on the country's resources, but merely reflect a transfer of the control over resources within the country.

9.3.6 Shadow Pricing

Shadow prices are economic accounting prices specifically estimated to be used in project appraisal to correct for market distortions. Shadow price corrections are most frequently applied on the following type of cost.

9.3.7 Foreign exchange (Shadow Exchange Rate)

Because economic analysis is concerned with the real cost of resources, an exchange rate higher than the official rate, i.e. the shadow rate should be used in estimating the foreign exchange value.

9.3.8 Economic Life

Depending on the nature of the project, the following economic life should be assumed:

Table 9.3.8: Economic Life of Projects

9.3.8.1 Civil Work and Buildings	20 – 50 years
9.3.8.2 General equipment	25 years
9.3.8.3 Transmission Equipment	
• Lines	25 – 45 years
• Cables	35 years
• Electro-technical	25 years
9.3.8.4 Distribution	
• Lines	25 – 45 years
• Cables	35 years
• Electro-technical	25 years
• Plant and machinery	25 years
9.3.8.5 Tools	10 years
9.3.8.6 Light Vehicles	5 years
9.3.8.7 Heavy Vehicles	5 years
9.3.8.8 Office Furniture	5 years
9.3.8.9 Office machine including typewriters	5 years
9.3.8.10 Office equipment including computers	3 years

9.3.9 Benefits

Each benefit arising form the implementation of the project should be captured and put in a different column, e.g. Sales Revenue that is obtained by multiplying the number of units or kWh to be sold by the average tariff applicable for the financial year. In cases where there is more than one stream of benefits these need to be summed up in a separate column for total benefits.

9.4 Cost- Benefit Analysis

9.4.1 Objective

The objective of cost-benefit analysis is to test the economic viability of the least-cost option that will have been selected. In other words cost-benefit analysis assesses the benefits accruing to the economy as a result of implementing a project.

9.4.2 Methodology

Cost-benefit analysis shall be based on a projection of economic costs and benefits over the lifetime of the project.

Once the costs and benefits have been established, a cash flow statement shall be set up for each year in the period of the analysis. The streams of benefit and cost should be discounted using the discount rate that is market based.

9.4.3 Discount Factors

These shall be calculated using the formula given below:

$1/(1+r)^n$

Where r is the discount rate as advised from time to time by ZETCO and n is a time variable.

For the base year n = 0 and for the following year it will be 1 (one) until the last year of the project's life.

9.4.4 Discount Rate

The discount rate or cost of capital is the rate of interest reflecting the value of money that is used to convert costs and benefit accruing at different times to equivalent values at a common time.

Using the Net Present Value (NPV), Internal Rate of Return (IRR), the Benefit to Cost ratio and the Least Cost Approach the viability of a project should be determined.

9.4.4.1 The Net Present Value (NPV)

The idea behind the NPV technique is that it **discounts** the cash flows generated by an asset back to the present day. Thus the NPV technique is concerned with the time value of money. The key consideration is on the **net present value,** which is the net of the initial (original) cost and the present value of all other cash flows. This is as opposed to the present value of the cash flows, which would simply be the sum of the original cash flows in each year.

The NPV shall be calculated as follows:

$$NPV = \frac{\Sigma NCF_t}{(1+r)^t} - I_0$$

Discounted cash flows are summed over life of project (N).

$NPV = CF_1 \times PVIF(K\%, 1year) + CF_2 \times PVIF(K\%, 2\ yrs) + \ldots CF_n \times PVIF(K\%, n\ yrs) - I_0$

Where CF_t = cash flow in year **t**
K = cost of capital or discount rate
n = period of investment
I_0 = Initial investment

Where future cash flows are an annuity (an equal amount),

$NPV = C^I F \times PVIF\ A(k\%, n\ yrs) - I_0$

Where CF = annual Cash Flow

PVIFA = present value interest factor of an annuity

The net present value decision criteria are the acceptance of a project with an NPV equal to or greater than zero and the rejection of a project with an NPV less than zero. When comparing mutually exclusive projects, the decision criterion is to accept the project with the highest NPV.

9.4.4.2 The Internal Rate of Return (IRR)

Whilst the net present value method provides useful information on project acceptance, the results from different projects need to be compared in conjunction with the internal rate of return (IRR) method.

The IRR is defined as the discount rate, which will result in an NPV of zero.

$0 = CF_1 \times PVIF(IRR\%, 1yr) + CF_2 \times PVIF(IRR\%, 2\ yrs) + \ldots CF_n \times PVIF(IRR\%, n\ yrs) - I_0$

To find the IRR one has to solve for the discount rate that gives an NPV that is equal to zero.

The IRR decision criteria shall be acceptance of a project with IRR equal or greater than the discount rate used in the analysis and rejection of a project with an IRR less than the cut off discount rate. In the case of comparing projects, the project with the highest IRR should be given top priority if the projects under consideration are otherwise comparable.

9.4.4.3 The Payback Period

The payback period measures the length of time it takes a project to repay its initial capital cost.

The payback period calculation is:

Number of years immediately prior to the year in which the payback period occurs	**PLUS**	The cash flow received during the year to take cumulative cash flow to zero The total cash flow during the year during which the payback period occurs

Payback Period = Initial Investment/Annual Cash flow (**If the project Cash flows are an annuity*)***

Or

$$\textbf{Payback Period} = t \left[\frac{I_o - C_t}{CF_{t+1}} \right] \quad \textbf{For unequal cashflows}$$

Where

t = is the last full year in which the cumulative cashflow are less than the initial investment

I_o = the initial investment

CF_{t+1} = the cashflow in year **t +1**

C_t = Cumulative cashflow

The method can be used where on, viable mutually exclusive projects the period of recovery of the initial investment a major consideration. The acceptable payback period can be decided by the company and may depend on the nature of the project and costs involved.

9.4.4.4 Benefit- Cost Ratio

Projects shall be analysed for benefit - cost ratio. This shall be calculated by dividing the total discounted benefits by the total discounted costs.

9.4.5 Financial Analysis

All projects shall be financially appraised. The financial analysis of a project estimates the profit accruing to the project-operating entity or to the project participants, whereas economic analysis measures the effect of the project on the national economy. For a project to be economically viable, it must be financially sustainable, as well as economically efficient. If a project is not financially sustainable, economic benefits will not be realized. Financial analysis and economic analysis are therefore two sides of the same coin and complementary.

In financial analysis all expenditures incurred under the project and revenues resulting from it should be taken into account. This form of analysis is necessary to:

- Assess the degree to which a project will generate revenues sufficient to meet financial obligations,
- Assess the incentives for producers, and
- Ensure demand or output forecasts on which the economic analysis is based are consistent with financial charges or available budget resources.

The steps presented below should be followed in undertaking financial analysis of projects.

9.4.5.1 Capital Costs

Costs quoted in foreign currency should be converted to local currency using the exchange rate ruling at the time of the analysis.

When costs are being incurred over a number of years they must be escalated by the relevant inflation index over the period they are being incurred.

Inflation index for base year is equal to 1 (one)
Inflation index for subsequent years = **Ifi** * (1+R)

Where:

Ifi is inflation index for previous year
R is inflation rate for the year under consideration written in decimal form. Appendix 1 shows the forecast exchange rates and inflation rates.

9.4.5.2 Total Capital/Investment Costs

Total capital or investment costs shall be obtained by adding the foreign and local costs.

9.4.5.3 Operating & Maintenance (O & M) Costs

O & M costs shall be obtained by multiplying the total capital/investment costs by 1.5% and then escalating the results by the inflation index for that year e.g. Σ(D1..Dn) *0.015**Ifi**.

Where D1..Dn are the capital costs

Ifi is the inflation index for the year under consideration

9.4.5.4 Electricity Production Costs

These shall be obtained by multiplying the units or kWh generated by the average electricity production cost applicable to the voltage level and then escalating using the inflation index for each year.

9.4.5.5 Total Costs

These shall be obtained by the summation of total capital costs, operating and maintenance costs and electricity production costs.

9.4.5.6 Benefits

These vary depending on the nature of project being considered. Each benefit stream should be put in a different column, e.g. sales revenue is obtained by multiplying the number of units or kWh to be sold in a particular year by the average tariff and then escalated by the inflation index for that year. In cases where there is more than one stream of benefits these need to be summated in the total benefits column.

9.4.5.7 Net Benefits or Net Cash Flows

This is obtained by subtracting the total costs from total benefits.

9.4.5.8 Discount Factors

These are calculated using the formula given below:

$1/(1+r)^n$

where r is the discount rate as advised from time to time.
n is the number of years of the project's useful life.

9.4.5.9 Net Present Values

These are obtained by multiplying the respective net benefits or net cash flows by the discount factor for each year of the project's lifetime or period of analysis. The total of this column gives us the NPV.

9.4.5.10 Cumulative Net Present Values

For the first or base year this is obtained by adding the net present value that has been calculated in the previous step (therefore cumulative NPV for first year equals NPV for first year). For subsequent years it is obtained by adding the cumulative net present value of the preceding year and the net present value of that year.

9.4.5.11 Discounted Benefits And Costs

Discounted benefits are obtained by multiplying the total benefits by the respective discount factors while the discounted costs are obtained by multiplying the total costs by the respective discount factors. Each column of the resultant figures needs to be summed.

9.4.5.12 Internal Rate Of Return (IRR)

This is obtained by using the formula below:

@ IRR (I , L5…L24)

Where:
@ is a lotus function,
IRR is the Internal Rate of Return,
I is an imaginary discount rate written in decimal form and usually ranges from 0.1 to 0.9 where 0.1 represent 10% and 0.9 represents 90% but can exceed unity.
(L5…L24) represents the net cash flows or net benefits from the first year to the last year of the period of analysis.

9.4.5.13 Benefit- Cost Ratio

This is obtained by dividing the total discounted benefits by the total discounted costs.

9.4.5.14 Assumptions

The following assumptions need to be stated where applicable.

i. Discount Rate
ii. O & M cost as a percentage of total investment costs
iii. Average Electricity Production Costs for period under consideration
iv. Average Tariffs for period under consideration
v. Load Growth Rate per Annum
vi. Load Factor or Power Factor
vii. Exchange rate
viii. Derivation of benefits for support projects

9.4.5.15 Expected Results

A viable project has to meet the criteria below :

I) At least 18 % internal rate of return (IRR)
II) A benefit-cost ratio of at least 1
III) A positive net present value (NPV)

9.5 Environmental Impact Assessment

All transmission and subtransmission projects shall be subjected to Environmental Impact Assessment (EIA). The Environmental Impact assessment shall be as per the Environmental Code developed and amended by ZERC from time to time, but should include the following issues.

9.5.1 Major Environmental Issues

The major environmental issues shall be assessed and incorporated in the planning stage as underscored in the following section.

9.5.1.1 Physical/Biological

All transmission and subtransmission projects shall be assessed on their physical and biological effects as follows:

- Pollution (water, soil, air, noise)
- Waste handling, storage and treatment (solid, water borne, gaseous)
- Effect on downstream surface water bodies (water quality, siltation, and change in regime).
- Effect on soil (erosion, compaction, quality)
- Loss or change of local and surrounding ecosystems e.g. cutting trees
- Effect on threatened/protected species
- Effect on protected areas or habitats
- Interference in animal populations (migration, free movement, behaviour, breeding)
- Any other physical and/or biological effects that could be of major concern to ZETCO or any segment of society

9.5.1.2 Social

All transmission and subtransmission projects shall be assessed on their social effects as follows:

- Effect on local community's way of life e.g. displacement
- Consultation, participation and support from local community
- Possible resistance to development
- Restriction of traditional access (pathways, religious sites, etc.)
- Threat to traditional cultural sites and artifacts
- Loss of access to traditional natural resources (grazing, firewood, medicines)
- Increased risks to public health (accidents, diseases, deteriorated water supply)
- Any other social effects that could be of major concern to ZETCO or any segment of the public

9.5.1.3 Economic

All transmission and subtransmission projects shall be assessed on their economic effects as follows

- Land tenure issues
- Effect on property values
- Permanent loss of land (opportunity cost)
- Effect on household incomes

- Effect of secondary and downstream economic activity
- Sustainability of chosen technology
- Compliance with international conventions/protocols
- Compliance with national policy, law and standards
- Compliance with voluntary standards (SAZ, ISO 9 000, 14 000)
- Any other economic effects that could be of major concern to ZETCO or any segment of society

9.5.2 Typical Impacts

During construction and operation of transmission and subtransmission projects and/or infrastructure special care and mitigation measures should be maintained to reduce or eliminate possible physical, social and economic environmental impacts.

9.5.2.1 Physical Impacts

Physical impacts that could arise due to the construction and operation of transmission and subtransmission infrastructure are:

- Damage to cultural resources and sites
- Visual intrusion from equipment and infrastructure
- Soil erosion from disturbed areas
- Degradation of surface water bodies by increase in suspended particulates
- Noise
- Contamination of ground water or surface water
- Soil contamination
- Any other physical impacts that could be of major concern to ZETCO or any segment of society

ZETCO shall put in place management steps to mitigate against negative possible physical impacts arising from the construction and operations of the transmission infrastructure. Such management steps shall include but not necessary limited:

- Ensuring appropriate siting
- Minimising clearing and blending vegetation
- Ensuring that safety procedures are followed
- Provision of surface drainage to meet quality standards before discharge of damaging effluent
- Cleaning up of spills (chemicals, diesel, oil, etc)
- Avoiding/minimising penetration of aquifers

- Controlling surface run off
- Selecting appropriate site(s) for solid waste disposal
- Availability of monitoring instruments to be placed at sensitive areas
- Carrying out appropriate surveys prior to disturbance to determine vulnerability of soil erosion
- Utilising technologies that minimise waste creation
- Minimise pollution at source
- Routine monitoring air quality
- Routine monitoring of water quality in rivers upstream and downstream of discharge point
- Routine monitoring of ground water through boreholes
- Minimising dust and particulate emissions
- Installation of appropriate pollution abatement devices on diesel equipment to ensure minimal emissions

9.5.2.2 Social Impacts

Social impacts that could arise due to the construction and operation of transmission and subtransmission infrastructure are:

- Disturbance of both humans and wildlife by noise from activities
- Injury/loss of life from accidents
- Competition with local cultures, traditions and life styles
- Increased demands on services and facilities in local communities
- Social and cultural conflicts affect community stability
- Secondary population growth
- Displacement of local communities
- Health problems associated with dust, smoke, STD, HIV, cholera, malaria, dysentery etc
- +Development of schools, hospitals and recreational facilities

ZETCO shall put in place management steps to mitigate against negative possible social impacts arising from the construction and operations of the transmission infrastructure. Such management steps shall include but not necessary limited to:

- Minimising conflict by employing locals where feasible
- Maintaining open dialogue with communities

- Ensuring that affected people are informed in advance and their rights communicated to them. In the event of problems, ensuring that problems are promptly addressed.
- Taking stock of population to be displaced, making an inventory of property loss and giving adequate compensation.
- Liaising with local community to assess their needs and ensuring minimal conflict between employees and the locals.
- Encourage project workers to participate in community affairs and open periodic dialogue with community leaders.
- Ensuring that safety equipment is available at all times.
- Ensuring that sites of cultural significance are demarcated and fenced or catalogued moved and re-sited.
- Ensuring that historical resources are archived or demarcated from the operating site
- Utilising appropriate dust control measures – waste spraying, wind breaks.

9.5.2.3 Economic Impacts

Economic impacts that could arise due to the construction and operation of transmission and subtransmission infrastructure are:

- Land use conflicts
- Induced development of other economic sectors
- Availability of a ready market for products
- Employment opportunities for local population

ZETCO shall put in place management steps to mitigate against negative possible economic impacts arising from the construction and operations of the transmission infrastructure. Such management steps shall include but not necessary limited to:

- Consulting with local land users in sitting access roads and other utilities
- Allowing other land uses on site if they are compatible with the operations.
- Employing as many locals as skills requirements permit
- Encouraging growth of secondary activities like shops, green markets, etc.

APPENDICES

APPENDIX I

PLANNING DATA REQUIREMENTS

General

i. Synchronous machine data
ii. Exciter data and models
iii. Governor data and models
iv. Power System stabilizer data (if installed)
v. Step-up transformer data (positive and zero sequence)
vi. Line impedance at the Connection Point (positive and zero sequence)
vii. System configuration (one-line diagram)
viii. Short circuit data
ix. Site load data
x. Point of delivery of excess generation
xi. Power factor limitations of the units
xii. Detailed location map

Unless otherwise indicated, the following information shall be supplied to ZETCO prior to connection and then updated as and when changes occur.

(a) Demand and network data

Connection capacity	Connection capacity required (MVA)
Measured and forecast data (annually)	For each point of supply, the information required is as follows: A 10-year demand forecast A description setting out the basis for the forecast The season of peak demand
User network data	Electrical single-line diagram of user network to a level of detail to be agreed with ZETCO, including the electrical characteristics of circuits and equipment (R, X, B, R0, X0, B0, continuous and probabilistic ratings) Contribution from customer network to a three-phase short-circuit at point of connection Information pertaining to the network connecting shunt capacitors, harmonic filters, reactors, SVC's, etc., to the point of supply for the purposes of conducting harmonic resonance studies.

	Electrical characteristics of all circuits and equipment at a voltage lower than secondary voltage levels of the customer connected to the Transmission System that may form a closed tie between two Connection Points on the Grid
Standby supply data (annually)	Source of standby supply (alternative supply point(s)) Standby capacity required (MW)
General information	For each new connection from a distributor or end-use customer, the following information is required: Number and type of switchbays required Load build-up curve (in the case of new end-user plant) Supply date (start of load build-up) Temporary construction supply requirements Load type (e.g. arc furnaces, rectifiers, rolling mills, residential, commercial, etc.) Annual load factor Power factor (including details of harmonic filters and power factor correction capacitors) Special requirements (e.g. quality of supply) Other information reasonably required by the service providers to provide the customer with an appropriate supply (e.g. pollution emission levels for insulation design)

Disturbing loads	Description of any load on the power System that could adversely affect ZETCO target conditions for power quality and the variation in the power quality that can be expected at the point connected to the Transmission System (The areas of concern here are, firstly, motors with starting currents referred back to the nominal voltage at the point of supply exceeding 5% of the fault level at the point of supply; and secondly, arc furnaces likely to produce flicker levels at the point of supply in excess of the limits specified in Section 3. The size limit for arc furnaces is subject to local conditions in respect of fault levels at the point of supply and background flicker produced by other arc furnaces and other equipment that will produce harmonics and/or negative and zero sequence current components, such as large AC/DC rectification installations.)

(b) Transmission System connected transformer data

	Symbol	**Units**
Number of windings		
Vector group		
Rated current of each winding		A
Transformer rating		MVA
Transformer tertiary rating		MVA
Transformer nominal LV voltage		kV
Transformer nominal tertiary voltage		kV
Transformer nominal HV voltage		kV
Tapped winding		HV/MV/LV/None (Delete what is not applicable)
Transformer ratio at all transformer taps		
Transformer impedance (resistance R and reactance X) at all taps	R+jX	% on rating MVATrans

For three-winding transformers, where there are external connections to all three windings, the impedance (resistance R and reactance X) between each pair of windings is required, measured with the third set of terminals open-circuit	ZHVMV, ZHVLV, & ZMVLV	% on rating MVATrans % on rating MVATrans % on rating MVATrans
Transformer zero sequence impedances at nominal tap		
Zero phase sequence impedance measured between the HV terminals (shorted) and the neutral terminal, with the LV terminals open-circuit		Ohm
Zero phase sequence impedance measured between the HV terminals (shorted) and the neutral terminal, with the LV terminals short-circuited to the neutral		Ohm
Zero phase sequence impedance measured between the LV terminals (shorted) and the neutral terminal, with the HV terminals open-circuit		Ohm
Zero phase sequence impedance measured between the LV terminals (shorted) and the neutral terminal, with the HV terminals short-circuited to the		Ohm

neutral		
Zero phase sequence leakage impedance measured between the HV terminals (shorted) and the LV terminals (shorted), with the Delta winding closed	Z_{L0}	Ohm
Earthing arrangement, including LV neutral earthing resistance and reactance core construction (number of limbs, shell or core type)		
Open-circuit characteristic		Graph

Transformer test certificates, from which actual technical detail can be extracted as required, are to be supplied on reasonable request.

(c) Shunt capacitor or reactor data requirements

For each shunt capacitor or reactor or power factor correction equipment or harmonic filters connected to or capable of being connected to a customer network, the customer shall inform ZETCO and, if required, shall provide ZETCO with the specific shunt capacitor or reactor data as well as network details necessary to perform primarily harmonic resonance studies. The customer shall inform ZETCO of his intention to extend or modify this equipment.

Any party to this code investigating a complaint about harmonic distortion shall have the right to request such additional information (including, but not restricted to, data from harmonic distortion measuring devices) from parties in the vicinity of the source of the complaint as may reasonably be required to complete the investigation.

Shunt capacitor or reactor rating	Rating (MVAr)
Reactor/capacitor/harmonic filter	(delete what is not applicable)
Location (station name)	
Voltage rating	KV
Resistance/ reactance/ susceptance of all components of the capacitor or reactor bank	
Fixed or switched	
If switched	Control details (manual, time, load, voltage, etc.)
If automatic control	Details of settings. If under FACTS device control (e.g. SVC), which device?

(d) Series capacitor or reactor data requirements

Series capacitors are installed in long transmission lines to increase load transfer capability. Series reactors are installed to limit fault levels, or to balance load sharing between circuits operated in parallel that would otherwise not share load equitably, or to balance load sharing on an interconnected network.

Reactor/capacitor	(Delete what is not applicable)
Location (specify substation bay where applicable)	
Voltage rating	KV
Impedance rating	Ohm or MVAr
Current rating (continuous and emergency, maximum times for emergency ratings)	Continuous: A Hours A Hours A Hours A

Note: if a series capacitor or reactor is located in a dedicated reactor or capacitor station (i.e. a substation built to hold only the series reactor or capacitor), the lines or cables linking it to each remote end substation must be specified as separate circuits under line or cable data.

Induction Motor data

Motor stating studies are done as part of grid impact studies carried out before a connection or modification on a connection point. All motors rated 500kW or more must therefore be specified as follows.

Parameter	Units
Rated Voltage	V/kV
Rated Power	kW
Rated Current	Amp
Rated Speed	
Rated power factor	
Starting Current	Amp
Starting Torque	
Starting power factor	
Peak Torque	
Inertia	

Generator planning data

Unless otherwise indicated, the following information shall be provided to ZETCO prior to connection and then updated as and when changes occur.

(a) Power station data

Generator name	
Power station name	
Number of units	
Primary fuel type/prime mover	For example, gas, hydro, fossil or nuclear
Secondary fuel type	For example, oil
Capacity requirement	Generation sent-out connection capacity required (MW)
"Restart after station blackout" capacity	Provide a document containing the following: Start-up time for the first unit (time from restart initiation to synchronise) and each of the following units assuming that restarting of units will be staggered
Black starting capacity	A document stating the number of units that can be black started at the same time, preparation time for the first unit black starting, restarting time for the first unit, and restarting time for the rest of the units
Partial load rejection capability	A description of the amount of load the unit can automatically govern back, without any restrictions, as a function of

	the load at the point of governing initiation
Multiple unit tripping (MUT) Risks	A document outlining all systems common to more than one unit that is likely to cause a MUT; discuss the measures taken to reduce the risk of MUT

(b) Unit data

Unit number	
Capacity	Unit capacity (MW)

	Units
Maximum continuous generation capacity:	MW
Maximum continuous sent out capacity	MW
Unit auxiliary active load	MW
Unit auxiliary reactive load	MVAr
Maximum (EL1) generating capacity	MW
Maximum (EL2) sent out capacity	MW
Minimum continuous generating capacity	MW
Minimum continuous sent out capacity	MW
Generator rating	MVA
Maximum lagging power factor	-
Maximum leading power factor	-
Governor droop	
Forbidden loading zones	MW
Terminal voltage adjustment range	KV
Short-circuit ratio	
Rated stator current	Amp
Time to synchronise from warm	Hour
Time to synchronise from cold	Hour
Minimum up-time	Hour
Minimum down-time	Hour
Loading rate	MW/min
Deloading rate	MW/min
Can the generator start on each fuel?	
Ability to change fuels on-load	
Available modes (lean burn etc.)	
Time to change modes on-load	

Control range for secondary frequency regulation operation	MW
Partial load rejection capability	% MW name plate rating
Minimum time unit operates in island mode	Hour
Maximum time unit operates in island mode	Hour

Description	**Data**
Capability chart showing full range of operating capability of the generator, including thermal and excitation limits	Diagram
Systems that are common and can cause a multiple unit trip	Description
Open-circuit magnetisation curves	Graph
Short-circuit characteristic	Graph
Zero power factor curve	Graph
V curves	Diagram

Documents	**Description**
Protection setting document	A document agreed and signed by ZETCO containing the following: - A section defining the base values and per unit values to be used - A single line diagram showing all the protection functions and sources of current and voltage signals - Protection tripping diagram(s) showing all the protection functions and associated tripping logic and tripping functions - A detailed description of settings relevant to the Transmission System connection. - A section containing a summary of all protection settings. - A section containing a summary for each of the protection relay programming details - An annex containing OEM information sheets or documents describing how the protection relays function -Information to Grid Users on protection schemes, fault levels and settings on the Grid circuits at the connection points - Information to generators and Grid Users on Standards pertaining to commissioning and maintenance procedures as per the stated Standard Documents on Section 7 of this Grid Code - Information to be furnished to ZETCO by Grid users pertaining to relevant protection schemes, fault levels and settings at the

	Connection Points. - Information to be furnished by ZETCO relevant to the generators protection schemes, fault levels and settings on the generators' equipment at the Connection Point.
Excitation setting document	A document agreed and signed by ZETCO containing the following: - A section defining the base values and per unit values to be used - A single line diagram showing all the excitation system functions and all the related protection tripping functions - An excitation system transfer function block diagram in accordance with IEEE or IEC standard models - A detailed description of setting calculation for each of the excitation system functions, discussion on function stability calculations, and detailed dial settings on the excitation system in order to achieve the required setting - A section containing a summary of all settings on a per unit basis - A section containing a summary for each of the excitation system dial settings/programming details. - An annex containing plant information data (e.g. OEM data) on which the settings are based - An annex containing OEM information sheets or documents describing the performance of the overall excitation system and each excitation function for which a setting is derived

Governor setting document	A document agreed and signed by ZETCO containing the following: - A section defining the base values and per unit values to be used - A single line diagram showing all the governor system functions and all the related protection tripping functions - A governor system transfer function block diagram in accordance with IEEE standard models - A detailed description of setting calculation for each of the governor system functions, discussion on function stability calculations, and detailed dial settings on the governor system in order to achieve the required setting - A section containing a summary of all settings on a per unit basis - A section containing a summary for each of the governor system dial settings/programming details - An annex containing plant information data on which the settings are based - An annex containing information sheets or documents describing the performance of the overall governor system and each governor function for which a setting is derived

(c) Reserve capability

The generator shall provide ZETCO with the reserve capability of each unit at each power station. The reserve capability shall be indicated as per each reserve category: instantaneous reserve, regulating reserve, emergency reserve, ten (10) minute reserve and supplemental reserve.

(d) Unit parameters

	Symbol	**Units**
Direct axis synchronous reactance	Xd	% on rating
Direct axis transient reactance saturated	Xsatd'	% on rating
Direct axis transient reactance unsaturated	Xunsatd'	% on rating
Sub-transient reactance unsaturated	Xqd""=	% on rating
Quad axis synchronous reactance	Xq	% on rating
Quad axis transient reactance unsaturated	Xunsatq'	% on rating
Negative phase sequence synchronous	X2	% on rating

reactance		
Zero phase sequence reactance	Xq0	% on rating
Turbine generator inertia constant for entire rotating mass	H	MW s/MVA
Stator resistance	Ra	% on rating
Stator leakage reactance	XL	% on rating
Poiter reactance	XP	% on rating
Generator time constants: Direct axis open-circuit transient Direct axis open-circuit Sub-transient	Tdo' Tdo"	sec sec
Quad axis open-circuit transient Quad axis open-circuit sub-transient Direct axis short-circuit transient Direct axis short-circuit sub-transient Quad axis short-circuit transient Quad axis short-circuit sub-transient	Tqo' Tqo" Td' Td" Tq' Tq"	sec sec sec sec sec sec
Speed damping	D	
Saturation ratio at 1 pu terminal voltage	S(1.0)	
Saturation ratio at 1.2 pu terminal voltage	S(1.2)	

(e) Excitation system

The generator shall fill in the following parameters or supply a Laplace domain control block diagram in accordance with IEEE or IEC standard excitation models (or as otherwise agreed with ZETCO) completely specifying all time constants and gains to fully explain the transfer function from the compensator or unit terminal voltage and field current to unit field voltage. Customers shall perform, or cause to be performed, small signal dynamic studies to ensure that

the proposed excitation system and turbine governor do not cause dynamic instability. The criteria for such dynamic instability shall be supplied by ZETCO. Where applicable, a PSS (power system stabiliser) shall be included in the excitation system to ensure proper tuning of the excitation system for stability purposes.

	Symbol	Units
Excitation system type (AC or DC)		Text
Excitation feeding arrangement (solid or shunt)		Text
Excitation system filter time constant	Tr	Sec
Excitation system lead time constant	Tc	Sec
Excitation system lag time constant	Tb	Sec
Excitation system controller gain	Ka	
Excitation system controller lag time constant	Ta	Sec
Excitation system maximum controller output	Vmax	p.u.
Excitation system minimum controller output	Vmin	p.u.
Excitation system regulation factor	Kc	
Excitation system rate feedback gain	Kf	
Excitation system rate feedback time constant	Tf	Sec

(f) Speed governor system, turbine and boiler models

The generator shall supply a Laplace domain control block diagram in accordance with IEEE standard prime mover models for thermal and hydro units (or as otherwise agreed with ZETCO), fully specifying all time constants and gains to fully explain the transfer function for the governor, turbine, penstocks and control systems in relation to frequency deviations and set-point operation.

(g) Control devices and protection relays

The generator should supply any additional Laplace domain control diagrams for any outstanding control devices (including power system stabilisers) or special protection relays in the unit that automatically impinge on its operating characteristics within 30 seconds following a system disturbance and that have a minimum time constant of at least 0,02 seconds.

(h) Unit step- up transformer

	Symbol	**Units**
Number of windings		
Vector group		
Rated current of each winding		Amps
Transformer rating		MVATrans
Transformer nominal LV voltage		KV
Transformer nominal HV voltage		KV
Tapped winding		
Transformer ratio at all transformer taps		
Transformer impedance at all taps (for three winding transformers the HV/LV1, HV/LV2 and LV1/LV2 impedances together with associated bases shall be provided)		% on rating MVATrans
Transformer zero sequence impedance at nominal tap	Z0	Ohm
Earthing arrangement, including neutral earthing resistance and reactance		
Core construction (number of limbs, shell or core type)		
Open-circuit characteristic		Graph

(i) Unit forecast data

The generator shall provide ZETCO with expected maintenance requirements, in weeks per annum, for each unit at a power station.

(j) Mothballing of generating plant:

Mothballing of generating plant is the withdrawal of plant from commercial service for six months or longer, with the intention of returning it to commercial service at a later date. Mothballing can have a profound impact on the operation and integrity of the Transmission System. Customers wishing to mothball generating plant shall supply ZETCO with the following information:

Generator name	
Power station name	
Unit number	
Date withdrawn	Date unit is to be withdrawn from commercial service
Return to commercial service	Envisaged return to service date (recommissioning tests completed and unit available for commercial service)
Auxiliary power requirements	

(k) Return to service of mothballed generating plant:

Once the customer has decided to return mothballed generating plant to service, ZETCO requires the information specified for new connections.

(**m) Decommissioning of generating plant:**
Decommissioning of plant is the permanent withdrawal from service of generating plant. ZETCO requires the following with a one-year notice period:

Generator name	
Power station name	
Unit number	
Date to be removed from commercial service	
Auxiliary supplies required for dismantling and demolition	kVA, point at which supply is require, duration

(n) **Long Term Demand and Supply Balance**

Generator Name	
Power Station	
Production Cost	Fixed production costs
	Variable production costs
	Start up costs
	Capital Costs
	Fuel costs
Plant maintenance data	Days and period of the year
Fuel consumption data	
Heat rates	
Heat values	
Environmental emission data	
Plant limitations and constraints	

(o) Operations Data

Generator reactive power capability	Generators to furnish ZETCO of the reactive capability of their machines as installed and as available for dispatch each time they declare available capacity for energy dispatch.
Load following capability	Generators to declare their load following capability and inform ZETCO of any variations in that capability
Reactive power compensation equipment	Grid users to furnish ZETCO information on installed reactive compensation equipment; its rating, controllability and availability
Power requirements	Grid users to furnish ZETCO of their power requirements including expected reactive power support at least a day ahead or any other such period as may be agreed between the two parties

APPENDIX II

SAMPLE CONFIDENTIALITY AGREEMENT FOR INFORMATION TRANSFER TO THIRD PARTIES

CONFIDENTIALITY AGREEMENT
BETWEEN
…….
(HEREINAFTER REFERRED TO AS THE INFORMATION OWNER)
AND
…….
(HEREINAFTER REFERRED TO AS THE RECIPIENT)
IN RESPECT OF INFORMATION SUPPLIED TO PERFORM THE FOLLOWING WORK:
……
(HEREINAFTER REFERRED TO AS THE WORK)
ON BEHALF OF
……..
(HEREINAFTER REFERRED TO AS THE CLIENT).

1. The Recipient agrees to treat all information (hereinafter referred to as the Information) received from the Information Owner, whether in hard copy or electronic format, as strictly confidential.
2. The Recipient agrees to disclose the Information only to persons who are in his permanent employ, and who require access to the Information to perform their duties in respect of the Work on behalf of the Client.
3. Persons other than those described in Clause 2 above, including but not restricted to temporary employees, subcontractors, and sub-consultants, shall enter into separate Confidentiality Agreements with the Information Owner prior to receiving the Information.
4. The Recipient undertakes to use the Information only to perform the Work on behalf of the Client, and for no other purpose whatsoever.
5. On completion of the Work, the Recipient shall at his expense return to the Information Owner all hard copy material and electronic media containing

the Information supplied to him by the Information Owner. The Recipient shall furthermore ensure that all duplicate copies of the Information in his or his employees' possession (electronic as well as hard copy format) are destroyed.

6. The Recipient shall take all reasonable measures to protect the security and integrity of the Information.
7. If requested to do so by the Information Owner, the Recipient shall forthwith at his expense return to the Information Owner all hard copy material and computer disks containing the Information supplied to him by the Information Owner. The Recipient shall furthermore ensure that all duplicate copies of the Information in his or his employees' possession (electronic as well as hard copy format) are destroyed.
8. The Recipient shall report any leak of the Information, howsoever caused, to the Information Owner as soon as practicable after he/she becomes aware of the leak, and shall provide the Information Owner with all reasonable assistance to ensure its recovery or destruction (as deemed appropriate by the Information Owner).

Signed at …… on this the …… day of …….

by (full name) ……in his/her capacity as

……. on behalf of ……, the Information

Owner ……

Signed at …… on this the …… day of …….

by (full name) ……in his/her capacity as

……. on behalf of ……, the Recipient

……